The CII ULFT Savings Study

Final Report

August 5, 1997

Sponsored by:

California Urban Water Conservation Council

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Sponsored by:

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EXECUTIVE SUMMARY

The California Urban Water Conservation Council's (CUWCC) mission is to oversee the implementation of urban water conservation best management practices (BMPs) as defined in the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU), and to improve the state of the art in water conservation practice and analysis. One of the BMPs relates to retrofitting commercial, industrial, and institutional (CII) sites with ultra-low flush toilets (ULFTs). Limited information regarding CII ULFT water savings, however, caused this BMP component to be deferred and then amended to require water suppliers to retrofit at least 1% of their customers by June 30, 1998. As part of this amendment, CUWCC was required to conduct a study to:

1. empirically estimate water savings per ULFT installation in different CII market segments

2. develop a practical approach for estimating the number of toilets by CII market segment within the service area of a given water agency.

CUWCC retained the services of Hagler Bailly Services, Inc. (Hagler Bailly) to conduct a study to achieve these objectives. This report describes the methods used and results produced.

Water Savings

Water savings estimates were derived by analyzing water billing records at 1,370 CII sites, served by 10 different California water agencies, that participated in ULFT retrofit programs between 1992 and 1996. The approach estimated water savings by comparing water use patterns over pre- and post-retrofit periods. We used multiple regression techniques to control for non-ULFT factors affecting water use and to minimize potential biases. We also conducted a telephone survey of 452 of the sites to validate retrofit information, identify potential non-ULFT water related changes at a site over time, and elicit information on customer satisfaction with ULFTs.

The water savings estimates derived in this study varied significantly by CII market segment, as ranked from highest to lowest in Table S-1. Most of the point estimates have relatively tight confidence intervals, especially for those market segments with large sample sizes (i.e., offices and retail establishments).

Table S-1
Savings per ULFT Installed
by Market Segment

Market Segment	Estimated Savings (gpd)	90% Confidence Interval (gpd)
1. Wholesale	57	19-94
2. Food Store	48	37-59
3. Restaurant	47	36-58
4. Retail	37	33-42
5. Automotive	36	22-50
6. Multiple Use	29	14-45
7. Religious	28	20-37
8. Manufacturing	23	15-32
9. Health Care	21	13-28
10. Office	20	17-23
11. Miscellaneous	17	11-23
12. Hotel/Motel	16	11-20

We conclude from this information the following:

- The best place to install ULFTs is at retail/wholesale and restaurant sites where average water savings range from 36 to 57 gallons per day (gpd) per ULFT. Within the retail market segment, we had sufficient observations to separately identify water savings associated with food stores and automotive (e.g., gas stations) sites, and found the water savings results comparable with other retail establishments. With respect to restaurants, we did not make a distinction between fast-food and sit-down, but about 90% of our sample included the sit-down type.

- Religious, manufacturing, health care, and offices all provide relatively modest savings in the 20 to 28 gpd range.

- Hotels/motels have the lowest estimated savings at only 16 gpd.

We were unable to determine ULFT water savings for the school and membership (e.g., health clubs) segments, largely because of lack of sites. In addition, we found it difficult to measure ULFT water savings at schools because irrigation water use (which tends to be large) is typically combined with indoor water use and recorded on the same water meter. This phenomenon tends to drown our ability to detect and isolate the ULFT water savings impact via billing analysis. The fact that statistically significant ULFT savings could not be estimated for schools and memberships does not necessary mean that ULFTs generate little or no savings in these facility types. Rather, limitations prohibited us from detecting savings with an appropriate level of statistical confidence. Thus, these two market segments would be good candidates for a more focused analysis that incorporates larger, more representative samples. In addition, anecdotal evidence gathered during this study suggests that some ULFTs may not hold up well under hostile conditions, such as may be seen in some school environments. We believe this postulation also warrants further study.

An additional objective was to test if water savings differ between sites in northern, central, and southern California. Results indicate that no statistically different distinctions exist.

Toilet Count Census

To achieve the second project objective, we developed a method for quantifying the number of CII toilets in a given water agency's service area. Obtaining this information can assist water planners in establishing long-term targets for ULFT replacements. When combined with per ULFT water savings estimates, this information can be used to set targets for ULFT water savings for an agency.

The toilet count method is based on identifying a linkage between number of toilets at a CII site and some other data parameter such as number of employees, students, or hotel rooms. To make the method practical, information about the identified data parameters came from sources readily accessible by water agency planners. We used building and plumbing codes as well as actual field observations of 1,350 CII sites in California to develop the functional linkage between number of toilets and the selected data parameters. Because of CII heterogeneity, CII sites are segmented into 11 relatively homogeneous subgroupings or market segments. This allows for the picking and choosing of data that best represent a particular segment. It also allows for a more customized approach in accounting for different CII customer mixes within a water agency service area.

After developing the toilet count method, we conducted a ground-truth testing. Prior to this CUWCC study, the San Luis Obispo (SLO) Community Development Department had developed estimates of the toilets in its CII sector based on building permit applications and their Land Use Inventory program. The total number of toilets estimated by the city of SLO within their CII sector was 11,200. The comparable estimate derived using our toilet count method is 11,767 toilets, or 4.8% above the SLO estimate. Although this is only one ground-truth experiment, this evidence supports the toilet count census method as a convenient means to derive approximate counts of toilets in the CII sector of a given water agency.

Additional Issues

Billing Data Analysis. Using billing data analysis to estimate water savings has both strengths and weaknesses. The major advantage is that it is comprehensive with respect to total water savings. ULFT water savings are a function of many variables that are difficult to measure individually, such as the extent of double flushing, toilet blockages, or other maintenance problems, and the effects of ULFT installation on water use for other end uses. A billing data analysis examines complete site water use and thus can provide a good estimate of net water savings, i.e., savings after accounting for such factors without having to measure them directly.

A weakness of using billing data is that the water associated with each end-use water application (e.g., toilet) cannot be directly specified. End-use information would be valuable to assess how some of the complicating factors mentioned above influence water savings. As an alternative to billing data, it is possible to collect water end-use data using sophisticated and specialized metering devices. Although use of these devices is relatively expensive and generally untested in the CII sector, its addition could answer some of these important and specific questions regarding ULFTs and would complement the results of this billing analysis study. In particular, we advocate an end-use study of ULFTs at schools.

ULFT Satisfaction. Although not a focus of this study, the telephone survey included questions on general satisfaction with ULFT performance. Responses were mixed. One question asked respondents to select on a scale of 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," how satisfied they have been with the performance of the ULFTs. The overall average score across all market segments was 3.8. In an open-ended question, 55% provided negative responses regarding ULFTs (e.g., toilets clog or double flush) and 45% provided neutral or positive statements (e.g., save water, no problems, like toilets). This issue merits additional study.

Database Standards. Finally, we strongly recommend that California water agencies standardize some core elements of their CII ULFT program tracking databases (e.g., SIC codes). There is great variation in the type and detail of tracking data currently being collected. Standardizing data fields for future collection would pose, in most cases, little additional cost. In contrast, collecting missing tracking data after the fact can be expensive and perhaps impossible. Therefore, up-front planning in tracking database design is a cost-effective means of improving future program planning, monitoring, and evaluation efforts.

CHAPTER 1
INTRODUCTION

Resource efficiency plays an important role in the economic, social, and environmental welfare of our society. Technological improvements are a major efficiency driver in applications as diverse as car engines, light bulbs, and toilets.

Over the last 20 years, there has been a dramatic advance in the water efficiency of toilets, going from toilets rated at over 5 gallons per flush (gpf), to 3.5 gpf, to under 1.6 gpf. Toilets classified as using 1.6 gpf or less are defined as ultra-low flush toilets, or ULFTs.

This study focuses on the water savings of ULFTs in the commercial, industrial, and institutional (CII) sector in California. Their distinctions are defined as follows[1]:

- *Commercial.* Any water user that provides or distributes a product or service, such as hotels, restaurants, office buildings, commercial businesses, or other places of commerce. These do not include residential users (single or multifamily); agricultural, mining, or construction users [Standard Industrial Classification (SIC) codes 07 through 17][2]; or other users that are considered industrial or institutional as defined below.

- *Industrial.* Any water users that are primarily manufacturers or processors of materials as defined by SIC codes 20 through 39.

- *Institutional.* Any water using establishment dedicated to public service. This includes schools, courts, churches, hospitals, and government facilities. All facilities serving these functions are to be considered institutions regardless of ownership.

1. This definition of CII customers was developed by the California Urban Water Conservation Council (CUWCC) CII subcommittee and adopted at a June 15, 1995, CUWCC plenary session. An exception is that we explicitly exclude SIC codes 07 to 17 from the commercial category.

2. Appendix A contains a listing of two-digit SIC codes.

1.1 ULFT HISTORY

It is important to understand the stock of existing toilets in the CII sector in order to be able to determine the impacts of ULFTs. This section provides a background.

Two general classes of toilets are currently prevalent in the United States. One is the tank-style or gravity-fed toilet, where water is stored in a toilet tank and, upon release, gravity-forced water flushes through the toilet bowl. The other type of toilet class uses flushometer-type valves. In this case, toilets use water pressure residing in incoming water pipes to flush water through the toilet. Other classes of toilets exist, but their market shares are currently low.[3]

The advantage of tank-type toilets is that they are less expensive both to install (require smaller pipes) and to purchase. This advantage makes them the clear choice in residential settings. The advantage of the flushometer-type toilets is that they are durable, require less maintenance, are more tamper proof, are less prone to develop slow leaks, tend to provide a cleaner bowl, and have a shorter flush cycle. Flushometer-type toilets are the clear choice in high-use and public settings.

In the CII sector, flushometer-type toilets predominate. There are, however, some exceptions. One notable exception is in the hotel/motel sector, where tank-type toilets constitute about 90% of toilets. The reason for their preference is that they are cheaper to install and also see limited traffic since a separate toilet is customarily provided within each room unit. Another situation where toilet tank-type toilets are popular is in small sites where the bathroom is usually used only by employees. Small offices and retail shops serve as examples. In general, however, flushometer-type toilets predominate and most likely constitute about 90% of the toilets in the remainder of the CII sector.

Toilet technology has been changing over time. Table 1-1 shows a historical summary of major events in technology changes in California. More detailed historical narratives of flushometer and tank-type toilets are provided in the next sections.

1.1.1 Flushometer-Type Toilets

Flushometer-type toilets have two distinctive parts: the valve and the toilet bowl fixture. Toilet manufacturers usually specialize in making one or the other. In 1977, the companies manufacturing toilet fixtures jointly moved from 5 to 3.5 gpf designs. The valve companies followed by changing their valves from 5 to 3.5 gpf. The change was swift and universal. Almost all sites installing new flushometer-type toilets after 1977 installed 3.5 gpf fixtures and valves.

3. For example, there is the flushometer-tank hybrid (pressure assisted) toilet and the blowout action flushometer-type toilet.

Table 1-1
Toilet Technology History in California

Time	Major Event
Prior to 1977	Both flushometer-type and tank-type toilets are 5 gpf or greater.
1977	Toilet manufactures universally come out with 3.5 gpf flushometer type toilets. Tank-type toilets of 5 or 3.5 gpf are available.
1983	California Plumbing Code change requiring 3.5 gpf toilets.
1992	California Plumbing Code change requiring ULFTs at 1.6 gpf.
1994	California code change requiring sale and labeling of ULFTs at 1.6 gpf.
1994-97	Federal plumbing code change requiring ULFTs at 1.6 gpf.

With respect to retrofitting existing 5 gpf toilet fixtures, in 1977 the valve companies came out with kits to change out 5 gpf valves with 3.5 gpf valves. Most 5 gpf fixtures flush well with 3.5 gpf valves. The extent to which retrofitting was done is difficult to ascertain.

Effective January 1983, the California Plumbing Code required installation of 3.5 gpf or less toilets in all new construction. This code change had little impact on flushometer-type toilets because of the manufacturers' change to 3.5 gpf toilets in 1977.

The manufacturers of both toilet fixtures and valves began offering 1.6 gallon models or ULFTs around 1989. The manufacturers, however, did not universally convert to the 1.6 gallon rated toilets. Instead they tended to produce both 1.6 and 3.5 gallon models. Effective January 1992, California again changed its plumbing code, mandating that all new construction install ULFTs (AB 2355, Filante). Because manufacturers were still making 3.5 gallon models for other states, however, the 3.5 gallon rated toilets were indirectly available and were being installed in new construction in California to some unknown degree. Another regulatory change in 1994 prohibited selling of non-ULFTs and mandated labeling of fixtures (SB 1224, Killea).

A federal plumbing code[4] change on January 1, 1994, requires ULFTs on a national level in new construction. Grandfathering of the switch makes the effective date January 1, 1997. After this

4. The Energy Policy Act of 1992 set minimum performance standards for toilets as established by the American Society of Mechanical Engineers (ASME)/American National Standards Institute (ANSI) Standards A116.19.2 and A116.19.6.

point, toilets manufactured in the United States are to be ULFTs. Thus the conversion from 3.5 to 1.6 gallon flushometer-type toilets has been gradual rather than swift.

Existing 5 or 3.5 gpf toilet fixtures do not flush properly on much less than 3 gallons. Hence, retrofitting a flushometer-type toilet to the 1.6 gpf rating requires replacing the toilet fixture, not just the valve.

1.1.2 Tank-Type Toilets

The history of tank-type toilets is somewhat different. First, there is a much greater variety of models. This, in part, is due to increased fashion demands in the residential sector, where these types of toilets are prevalent.

Before 1977, almost all tank-type toilets in California had a 5 to 7 gpf rating. In 1977, manufacturers came out with 3.5 gpf tank-type toilets in parallel with the 3.5 gpf flushometer-type toilets. However, in contrast to the flushometer-type of toilets, manufacturers did maintain production of the 5 plus gpf tank-type toilets. As a consequence, the conversion to 3.5 gpf tank-type toilets was more gradual.

Retrofitting the 5 plus gpf toilets was done to some degree. This usually resulted from installation of displacement devices (e.g., bags, dams, bricks, bottles) in the toilet bowl. These measures saved approximately 0.5 to 2 gallons; greater displacement interferes with successful toilet operation.

The January 1983 California Plumbing Code change requiring 3.5 gpf or less toilets in all new construction had a significant impact on the tank-type toilet market by officially eliminating access to the 5 plus gpf toilet fixtures.

In the late 1980s, toilet-tank ULFTs started to become generally available to the public.[5] Again, manufactures did not universally adopt the new technology (ULFTs), but offered them in conjunction with 3.5 gpf toilets. As with the flushometer-type toilets, retrofitting 3.5 gpf toilets to become 1.6 gpf toilets is not promoted; new toilet bowl design is needed with the low 1.6 gpf operation.

The 1992 California Plumbing Code change shifted the market to 1.6 gpf toilets. Although some new construction after this point installed 3.5 gpf tank-type toilets (from old inventories and access to 3.5 gpf toilets in other states), it is believed that over 90% of new installations are of the

5. ULFTs originated in Scandinavia in the 1970s and were introduced to the United States in the early 1980s, but were not widely available to the general public.

1.6 gpf rating. With the passage of a California regulation (SB 1224) and the federal plumbing code change in 1994, 3.5 gpf toilet sales are becoming more rare.

1.1.3 Current Toilet Efficiency

Given the history of manufacturing and plumbing code changes, it is difficult to assess the water efficiency mix associated with the stock of toilets currently existing in the CII sector. To get an empirical estimate, we reviewed gallon per flush information for 818 CII sites located within the service territory of the Metropolitan Water District (MWD) of Southern California. These sites participated in a comprehensive water audit program in which a trained auditor inspected each facility (see Chapter 3 for more details about the database). Results of our analysis are shown in Table 1-2. ULFTs have only 5 to 7% market penetration. The 3.5 gpf toilets are the most common. It is significant to notice that almost 20 years after the 1977 manufacturers' change to 3.5 gpf flushometer-type toilets, 34% are still of the 5 gpf variety. The change-out of tank-type toilets has been even slower, where 44% are still 5 gpf.

Table 1-2
MWD CII Audit Database gpf Estimates

gpf Estimated Rating	gpf Observed Range	Toilet Type: Flushometer % of Toilets	Toilet Type: Tank % of Toilets
1.6	Up to 2.0	7%	5%
3.5	2.0 to 4.0	59%	51%
5	Over 4.0	34%	44%
Total %		**100%**	**100%**
Total Toilets		**21,071**	**17,446**

1.2 ULFT RETROFIT PROGRAMS IN CALIFORNIA

The useful life of a toilet can exceed 30 years. Hence, while laws requiring installation of ULFTs in new construction and in replacements are helpful, it takes many years to replace the existing stock of non-ULFTs in this manner.

To catalyze the conversion to ULFTs in existing buildings, a number of water agencies in California started ULFT retrofit programs. Although the details of the ULFT programs vary among agencies and over time, the programs have common traits. Most water agencies offer financial rebates of about $50 to $150 per ULFT retrofit. This incentive goes to partially offset the cost of the new toilet and, hence, dramatically decrease the investment payback period of the ULFT to the customer. These programs also serve to educate customers about the advantages associated with the ULFTs.

The first major CII ULFT retrofit program started in Santa Barbara in 1988. Faced with severe water supply deficiencies, Santa Barbara was compelled to take the lead. Many other large urban water retailers followed in the early 1990s.

1.3 LITERATURE ON CII ULFT WATER SAVINGS

Research on the efficacy of ULFTs in the CII sector has been limited. No single study or compilation of studies provides the comprehensive information needed by water conservation practitioners to identify the best opportunities to install ULFTs. Unlike the residential sector, the CII sector is extremely diverse and, hence, it is important to differentiate among conditions.

One previous study investigated ULFT water savings in 70 public facilities in San Diego, California.[6] Installation of ULFTs resulted in net water savings of 20 gallons per day (gpd) for police stations, 28 gpd for fire stations, 76 gpd for libraries, and 117 gpd for recreational and other miscellaneous public sites. Another study looked at ULFTs at an airport and found water savings to be 1.05 gallons/patron for men and 1.99 gallons/patron for women.[7] A study in San Jose, California, looked at 21 diverse sites and found diverse water savings estimates.[8]

1.4 PROJECT OBJECTIVES

The California Urban Water Conservation Council (CUWCC) was formed in 1991 as part of the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU). Some 200 water suppliers, public advocacy groups, and other interested parties are now signatories to the MOU and members of the council. Urban water suppliers participating in the council serve about 90% of California's urban population.

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6. A&N Technical Services, Inc. 1994. Public Facilities Toilet Retrofits. Report submitted to The Metropolitan Water District of Southern California.

7. Center for Environmental Engineering, Stevens Institute of Technology. 1992. A Laboratory and Field Evaluation of 1.6 gpf Water Closets in a Commercial Setting. Report No. R246. Report submitted to the City and County of Denver, Colorado.

8. W.L. Corpening and Associates. 1995. Performance Evaluation of ULFTs in CII Settings. Report submitted to the City of San Jose Office of Environmental Services.

CUWCC's mission is to oversee the implementation of urban water conservation best management practices (BMPs) as defined in the MOU, and to improve the state of the art in water conservation practice and analysis. One of the BMPs relates to retrofitting CII sites with ULFTs. Because of limited information regarding water savings, the BMP component addressing ULFT retrofits in the CII sector was deferred until July 1, 1995. The BMP was subsequently amended to require water suppliers to retrofit at least 1% of their customers by June 30, 1998. As part of this amendment, CUWCC was required to complete studies to:

1. empirically estimate water savings per ULFT installation in different CII market segments
2. develop a practical approach for estimating the number of toilets by CII market segment within the service area of a given water agency.

CUWCC retained the services of Hagler Bailly Services, Inc. (Hagler Bailly) to conduct a study to achieve these objectives. This report describes the methods used and results produced.

Chapter 2 of this report describes the method and results of the ULFT water savings task. This includes a description of the data collected, the quantitative techniques employed, and the estimated water savings by CII market segment.[9] Chapter 3 addresses the toilet count task and illustrates the method using a California water agency as a case study (i.e, city of San Luis Obispo). Chapter 4 recaps the savings analysis and discusses additional issues, including cost-effective targeting of market segments for ULFT retrofits, the advantages and disadvantages of billing analysis to estimate ULFT savings, our survey findings on customer satisfaction with ULFTs, and the need for standardization in program tracking data.

9. We should qualify that we were constrained by data and budget limitations and that we acknowledge that there are alternative quantitative methods for estimating ULFT water savings. Given these caveats, we believe that we have developed a reasonable foundation and reasonable estimates of ULFT savings under the situations described. We encourage future refinement and study in this area.

CHAPTER 2
ULFT WATER SAVINGS ESTIMATION

What are the water savings associated with CII ULFT installations? This information is vital to cost-effectively targeting CII sites and in setting appropriate water conservation policy. In this chapter, we describe each component of our empirical investigation of the water savings question. Specifically, we describe the water agencies and types of CII sites involved, discuss the sources and types of data, explain the modeling approach, and present the ULFT water savings estimates.

Our overall approach is to analyze whole-premise (water use aggregated over all end uses at a site) water billing records for a large sample of CII sites participating in ULFT replacement programs between 1991 and 1996 in California. The approach estimates water savings by comparing water use patterns over pre- and post-retrofit periods. We use multiple regression techniques to control for non-ULFT factors that influence water use and to minimize potential biases in estimation. In addition to water use billing data, our approach uses ULFT program tracking data, weather data, water and sewer price data, information on non-ULFT water conservation measure installations, and data collected through a telephone survey of customers conducted by Hagler Bailly.

Examining total whole-premise water use rather than solely toilet water use is an advantage because, when ULFT retrofits take place, a number of confounding factors come into play to complicate the water savings question.[1] These factors are usually difficult to observe directly because of a lack of data. However, examination of whole-premise water use, and of the way in which it changes following ULFT installation, allows the researcher to account for such complicating factors without directly observing their magnitudes. These complicating factors include the following:

- *Pre-Retrofit Toilet Heterogeneity.* ULFT water savings will depend, partly, on the water efficiency of the toilets replaced. Water savings will tend to be higher when the pre-retrofit fixtures are 5 gpf toilets as opposed to 3.5 gpf toilets. Little information is often included in existing CII ULFT tracking databases, however, on the efficiency of replaced toilets.

- *ULFT Heterogeneity.* Toilets can perform differently in the field than in the laboratory. There are two forms of ULFT heterogeneity to recognize. The first concerns the gpf variation within the same make and brand of toilet (and valve); just because a toilet has a 1.6 gpf rating does not mean that it flushes 1.6 gallons each time. Identical toilets can

1. The billing analysis approach also has weaknesses as described in Section 4.2.

experience significant gpf differences given differences in water pressure, wear and tear, and maintenance, among other factors. Variations can easily run from 1.3 to 1.9 gpf or more. The other form of heterogeneity arises from differences in gpf among different toilet makes and brands. This type of variation is most pronounced with toilet tanks because of the diversity of products.

- ***Flush Counts.*** Volumetric water savings from ULFT retrofits will increase with toilet use. Unfortunately, in contrast to the residential sector, we expect that toilet usage rates vary greatly within the CII sector. Hotels, restaurants, office buildings, industrial sites, food processors, and hospitals, for example, all use water for different purposes and to varying degrees, including toilet use. Hence, no one single ULFT water savings estimate can be assumed to accurately represent the whole CII sector.

- ***Double-Flush Propensity.*** "Double flushing" occurs when more than one flush is required to remove wastes from the toilet bowl. Some toilets perform better than others with respect to the need for double flushing. Obviously, net water savings associated with ULFTs decrease as double flushing increases.[2,3]

- ***Toilet Leaks.*** Some toilets and designs tend to leak more than others. Toilet leakage can be a significant component of total toilet water use in some situations.

- ***Toilet Maintenance.*** Toilet blockages or other maintenance problems can dramatically alter toilet water use. Some evidence suggests that some existing ULFTs in the CII sector require more maintenance to operate properly.[4,5]

- ***Psychological Impacts on Other End Uses.*** Water savings resulting from ULFTs may cause changes in other site water end uses. For example, ULFT water savings may heighten the topic of water conservation and lead to additional conservation steps. This effect is sometimes termed "spillover." Or, ULFT water savings may be used to justify new end uses such as increases in irrigating landscape. This effect is sometimes termed

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2. Evidence of differences in double flushing are documented in *Customer Satisfaction Survey Final Report*, prepared by Westat, Inc. for the New York City Department of Environmental Protection, December 1996.

3. The Wirthlin Group. 1995. *Ultra-Low-Flush Toilet Users: A Comparison of 1992/1995 Survey Results*. The Los Angeles Department of Water and Power. October.

4. Konen, T.P., et al. 1992. *A Laboratory and Field Evaluation of 1.6 gpf Water Closets in a Commercial Setting*. City and County of Denver, Colorado. October.

5. W.L. Corpening and Associates. 1995. *Performance Evaluation of Ultra Low Flush Toilets in CII Settings*, City of San Jose Office of Environmental Services. June.

"snapback" or "rebound."[6] The magnitudes of such effects are difficult to ascertain and undoubtedly vary by case.

Again, a major advantage of the whole-premise billing analysis approach is that it allows the researcher to account for such factors and thereby produce an estimate of "net" savings, without directly measuring each individual factor. This is because the factors above are embedded within the difference between post- and pre-retrofit water use at the whole-facility level. In addition, because of heterogeneity in CII toilet use, it is useful to segment CII sites into similar subgroups.

Sections 2.1 through 2.3 of this chapter describe the water agencies included in the study, their ULFT program tracking data, and the market segmentation of the CII sites included in our sample, respectively. Sections 2.4 through 2.8 describe the sources of data used in our analysis. Section 2.9 explains the water savings models used, and Section 2.10 presents the resulting estimates of ULFT water savings by market segment.

2.1 WATER AGENCY PARTICIPANTS

We recruited and selected 10 water agencies to participate in this project. In looking for candidates, we sought water agencies that:

- had relatively large CII ULFT retrofit programs
- had necessary billing and tracking data
- provided a geographic mix from northern, central, and southern California.

To identify water agencies with large CII ULFT programs, we reviewed results of a CUWCC survey of CII ULFT programs in California. The survey identified 5 water agencies that had retrofitted over 100 CII sites, and over 20 more with more modest totals. All five of the largest agencies were asked and agreed to participate in this study. Through networking, we also uncovered other agencies that had not responded to the CUWCC survey, but had significant CII ULFT retrofit programs. Two agencies were added this way. The remaining three agencies were selected from the remaining CUWCC survey group based on geographic location, content of ULFT tracking records, and willingness to participate. Table 2-1 lists the 10 participating agencies.

6. It is important to note that any "snapback" or "rebound" associated with ULFTs provides the customer with additional benefits that are not accounted for in a net water use analysis. For example, the water saved from ULFTs may be used to increase water use for another end use (such as outside irrigation), with no additional water cost to the customer.

Table 2-1
Participating Water Agencies

Region	Water Agency
Southern California	City of Anaheim
Southern California	City of San Diego
Southern California	San Diego County Water Authority
Southern California	City of Santa Monica
Central California	City of San Luis Obispo
Central California	City of Santa Barbara
Central California	City of Ventura
Northern California	East Bay MUD
Northern California	Marin Municipal Water District
Northern California	City of San Francisco

2.2 ULFT PROGRAM TRACKING DATA

For each of the participating agencies, we collected available ULFT program tracking data. Tracking data sought for each site included:

- customer name
- site address
- account/meter number(s)
- CII market segment (SIC code)
- contact name
- contact phone number
- total toilets at site
- ULFT retrofit date(s)
- number of ULFT retrofits
- ULFT type
- pre-retrofit toilet type.

In addition, we collected information on service area boundaries, general historical descriptions of the CII ULFT retrofit programs, the structure of and data fields in the billing databases, and information regarding water and sewer rates.

Upon delivery of the ULFT tracking data, we sought to define the historical period on which to focus in this investigation. We selected the period spanning 1991 to 1996. The reasons for choosing to start the analysis in 1991 are the following:

- Pre-1991 water billing data were not available in electronic form at some agencies. We wanted at least one year of pre-retrofit billing data.
- After screening sites that had insufficient program tracking and/or billing data, the pre-1991 retrofit sites accounted for only a small fraction of the total ULFT retrofit sites.

Based on this decision, we subsequently collected billing records for each CII ULFT site over the 1991 to 1996 period. Because some of the larger sites have more than one water meter, we aggregated water use over all meters at a site when relevant. We did not, however, include meters when it was known that they did not serve sanitary purposes. Irrigation meters, for example, were excluded.

2.3 CII MARKET SEGMENTS

The CII sites participating in the ULFT retrofit programs are quite diverse. Hence, it is useful to group sites with similar characteristics into subclasses or market segments. This step allows more precise judgments as to the impact of ULFTs within specific segments.

Generally, we defined market segments using associations with four-digit SIC codes. SIC codes provide a detailed description of site activity. For example, an SIC of 5812 identifies a restaurant and an SIC of 8211 identifies an elementary or secondary school. The detailed SICs allow us a great deal of flexibility in how subclasses are defined. Because there are hundreds of individual SIC codes, however, we found it prudent to condense SIC codes into segments expected to have similar patterns of water consumption. For example, SICs in the range 2000 to 3999 are all grouped under the industrial market segment.

2.3.1 SIC Code Determination

Unfortunately, most agencies did not have SIC code data linked to their customers. In the absence of SIC information, we estimated an SIC code for each site through a combination of methods. In some cases, water agency data included a general facility description that corresponded with, or allowed us to identify, the appropriate CII segment (e.g., hotel/motel). In other cases, SIC codes could be determined from a customer name (e.g., McDonalds or Magnolia High School). Facility service address information or contact information, if available, could also be used to determine the SIC for a given site.

When a water agency did not provide SIC information, the sequential approach used to determine SICs was as follows:

- If facility names or descriptions were available and sufficiently detailed, then these were used as a basis for assigning a site SIC.
- If a service address was available, then an attempt was made to determine an SIC by an address lookup in standard commercial databases.
- If a contact name and phone number were available, then an attempt was made to determine an SIC by calling that contact.
- In cases where none of the above alternatives produced an SIC determination, site information was returned to the appropriate water agency for further research.

Table 2-2 provides selected details, by water agency, on the extent of available data and the methods used to identify site SIC codes.[7]

2.3.2 Market Segment Definition

How many market segments should be defined? On one hand, a high degree of segmentation is sought to improve the homogeneity of market segment members. On the other hand, we want adequate numbers of sites in each segment for the purpose of statistical modeling. A balance between these two competing objectives is needed. In most cases a natural and obvious definition is apparent. Churches, hotels/motels, offices, restaurants, schools, and retail were the most common types of sites participating in the ULFT retrofit programs. To advance the degree of the segmentation, we stratified major groups when sufficient numbers of sites were available.

In other situations, it was not clear how a site should be classified. Some sites, for example, served multiple purposes. A site could have retail operations on the ground floor with office space above. We created the market segment "multiple use" to account for these sites. In other cases,

7. Sites in each water agency were assigned an SIC based on the approach outlined above. It should be noted that, because of imperfect information, some sites may have been misclassified with respect to SIC, leading to possible misclassification error in the analysis. For this reason, it is important for agencies in the future to accurately assign an SIC code to each participant in the tracking system.

Table 2-2
SIC Determination by Water Agency

Agency	Means of SIC Determination
Anaheim	General site description field.
San Diego	SIC provided.
SDCWA	Telephone call to site contacts.
Santa Monica	Used SIC lookup database using customer name and site address as inputs. Also used wastewater general use code.
San Luis Obispo	SIC provided.
Santa Barbara	Used SIC lookup database using customer name and site address as inputs. For those sites not identified, called site contact.
Ventura	General site description field.
EBMUD	General site description field.
Marin	Used SIC lookup database using customer name and site address as inputs. For those sites not identified, called site contact.
San Francisco	SIC information was available. In most cases, however, the SIC had been set to 9991 (nonclassifiable establishments). In these cases, SICs were assigned based on facility name, description, and address information.

insufficient sites existed to warrant a separate market segment. When fewer than 10 sites were available for a particular market segment, we assigned the sites to the market segment "other."[8]

We developed 18 market segments to characterize all the sites. This number allows for a high level of segmentation given the types and limited number of sites participating in the ULFT retrofit programs. In the regression analyses of billing records (discussed in Section 2.9), we collapsed these 18 market segments to a list of 14. For example, fast food and sit-down restaurants were combined. This step was necessary in order to yield strata with sufficient numbers of observations for statistical analysis.

8. The criterion that market segments with fewer than 10 sites were assigned to an "other" segment was based on our past sampling design experience. In our opinion, creating separate market segments when fewer than 10 sites exist would have resulted in some market segments being too small to estimate statistically significant savings impacts from the final telephone survey samples. Nevertheless, this segment is heterogenous and inferences concerning this segment should be made with great care.

2.3.3 Market Segment Distribution

Table 2-3 shows the number of CII sites for each market segment, by water agency.[9] After screening out cases with insufficient ULFT tracking or water use billing data, a total of 1,370 CII sites were available for our study from the 10 water agencies. The number of sites coming from each agency, however, differs greatly. The water agencies can be divided into two tiers: large and small. San Diego, Santa Monica, Marin, San Luis Obispo, and Santa Barbara contribute over 90% of the ULFT sites. Although the remaining five agencies do not provide many observations in total, they do significantly contribute to selected market segments. For example, strategic help is offered by Anaheim with schools, SDCWA with manufacturing, and Ventura with restaurants.

With respect to number of sites, the top five market segments are offices, other, restaurants, retail, and religious. The office building (private and government) segment has 24% of the total. San Diego and, to a lesser extent, Marin offer most of these sites. Restaurants (fast food and sit-down) constitute 12% of sites and are in most water agencies' areas. Retail is 10% of the sites, mainly in San Diego, Santa Monica, San Luis Obispo, Santa Barbara, and Marin. Religious (churches) makes up 6% of the sample.

Table 2-4 shows the number of ULFTs retrofitted, by CII market segment and water agency. The number of ULFTs totals 9,958. Again, the dominance of the five large agencies is apparent: almost 90% of the ULFTs are from San Diego, Santa Monica, San Luis Obispo, Santa Barbara, and Marin. The top five subclasses, with respect to number of ULFTs, are hotels/motels, schools, offices, other, and restaurants. This ranking is quite different from that based on the number of sites. This results because the hotel/motel and school sites tend to have more ULFT retrofits at each site. Hotels/motels installed 33% of ULFTs. Schools, offices, other, and restaurants installed 12%, 14%, 13%, and 4% of ULFTs, respectively.

A more detailed distribution of the number of ULFTs installed at each site is shown in Table 2-5. The percentage of sites installing one ULFT is 35%. The percentage of sites installing two ULFTs is 23%. Hence, 58% of the CII sites had two or fewer ULFT retrofits. The percentage of sites with five or fewer ULFT retrofits is 78%. This evidence shows that CII sites considered in this study have a large proportion of relatively small sites.

Finally, Table 2-6 shows the number of CII sites by water agency and year of retrofit. All of the ULFTs were retrofitted from 1991 through 1996. The majority of sites were retrofitted in either 1994 (30% of all sites) or 1995 (25% of all sites). Only 18% of all sites were retrofitted before 1993 (6% in 1991 and 12% in 1992).

9. The membership segment combines health clubs, gyms, and recreational centers.

Table 2-3
ULFT Sites by Agency and Market Segment

CII Market Segment	Water Agency: Southern CA: Anaheim	San Diego	SDCWA	Santa Monica	Central CA: SLO	Santa Barbara	Ventura	Northern CA: EBMUD	Marin	San Francisco	Total	Relative %
Automotive		23		5	1	3			4		36	3%
Food Store		6		1	1	4			8	2	22	2%
Health Care		23		9	11	4	1		14	1	63	5%
Hotel/Motel		31		10	8	10			7	2	68	5%
Manufacturing		30	5	7		1			1	1	45	3%
Membership				4			4		10	1	19	1%
Multiple Use				9		1			24		34	2%
Office — GV				12	1	1			4		18	1%
Office — PV		200		23	9	20	1	2	52	2	309	23%
Other		70		42	13	19	2		37	1	184	13%
Pub. Fac.				49							49	4%
Religious		48	2	7	4	1			21		83	6%
Restaurant — FF				1	4		8		1	4	18	1%
Restaurant — SD		42		9	38	7	30		18	11	155	11%
Retail		49		20	24	26	1		19	1	140	10%
School — ES			1	16			11	1	1		30	2%
School — HS	5			2			2	1			10	1%
Unknown			1	64		7				3	75	5%
Wholesale		6			2	3			1		12	1%
Total	5	528	9	290	116	107	60	4	222	29	1,370	
Relative %	0%	39%	1%	21%	8%	8%	4%	0%	16%	2%		100%

Notes: 92% of sites from Marin, San Diego, SLO, Santa Barbara, and Santa Monica.
61% of sites from Southern CA.
21% of sites from Central CA.
19% of sites from Northern CA.

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Table 2-4
Number of ULFTs by Agency and Market Segment

	Water Agency											
	Southern CA				Central CA			Northern CA				
CII Market Segment	Anaheim	San Diego	SDCWA	Santa Monica	SLO	Santa Barbara	Ventura	EBMUD	Marin	San Francisco	Total	Relative %
Automotive		38		9	2	6			6		61	1%
Food Store		7		1	1	8			13	3	33	0%
Health Care		60		103	18	19	2		42	1	245	2%
Hotel/Motel		1,021		825	653	299			396	72	3266	33%
Manufacturing		112	93	84		1			2	3	295	3%
Membership				18			25		31	4	78	1%
Multiple Use				33		2			76		111	1%
Office — GV				202	3	7			5		217	2%
Office — PV		680		202	20	44	12	25	176	6	1,165	12%
Other		553		383	44	123	15		183	3	1,304	13%
Pub. Fac.				392							392	4%
Religious		172	2	62	11	9			104		360	4%
Restaurant — FF				2	11		21		2	6	42	0%
Restaurant — SD		93		19	121	15	92		37	18	395	4%
Retail		90		37	47	40	2		49	100	365	4%
School — ES			2	443			280	24	1		750	8%
School — HS	187			159			38	11			395	4%
Unknown			1	450		10				4	465	5%
Wholesale		10			4	3			2		19	0%
Total	187	2,836	98	3,424	935	586	487	60	1,125	220	9,958	
Relative %	2%	28%	1%	34%	9%	6%	5%	1%	11%	2%		100%

Notes: 89% of ULFTs from Marin, San Diego, SLO, Santa Barbara, and Santa Monica.
66% of ULFTs from Southern CA.
20% of ULFTs from Central CA.
14% of ULFTs from Northern CA.

Table 2-5
Sites by ULFT Count and Market Segment

CII Market Segment	ULFT Count at Site								All Sites	Relative %
	1	2	3 to 5	6 to 10	11 to 20	21 to 50	Over 50	Unknown		
Automotive	21	10	5						36	3%
Food Store	15	5	2						22	2%
Health Care	25	15	12	5	5	1			63	5%
Hotel/Motel	8	7	7	10	7	8	21		68	5%
Manufacturing	12	12	11	3	4	2	1		45	3%
Membership	4	5	3	7					19	1%
Multiple Use	8	11	11	3	1				34	2%
Office — GV	4	3	2	5	2	1	1		18	1%
Office — PV	124	63	69	32	17	2	2		309	23%
Other	71	41	35	19	9	5	4		184	13%
Pub. Fac.	2	2	19	15	9	2			49	4%
Religious	25	16	19	13	10				83	6%
Restaurant — FF	4	11	2	1					18	1%
Restaurant — SD	43	62	37	10	1			2	155	11%
Retail	79	32	22	3	1		1	2	140	10%
School — ES	4	1	2		4	17	2		30	2%
School — HS					2	7	1		10	1%
Unknown	19	15	16	15	6	4			75	5%
Wholesale	5	7							12	1%
Total	473	318	274	141	78	49	33	4	1,370	
Relative %	35%	23%	20%	10%	6%	4%	2%	0%		100%

Table 2-6
Number of CII Sites by Agency and Retrofit Year

Retrofit Year	Water Agency: Southern CA: Anaheim	San Diego	SDCWA	Santa Monica	Central Coastal CA: SLO	Santa Barbara	Ventura	Northern CA: EBMUD	Marin	San Francisco	Totals	Relative %
1991		7		78						1	86	6%
1992		71		58	2	25	7			1	164	12%
1993		59	1	66	10	40	12			3	191	14%
1994		172	6	58	30	35	9		95	3	408	30%
1995	5	120	2	20	49	7	25		99	11	338	25%
1996		99		10	25		7	4	28	10	183	13%
Totals	5	528	9	290	116	107	60	4	222	29	1,370	
Relative %	0%	39%	1%	21%	8%	8%	4%	0%	16%	2%		100%

82% of sites retrofitted 1993 to present.
68% of sites retrofitted 1994 to present.
38% of sites retrofitted 1995 to present.

2.4 WATER USE DATA

The only water use information available to make pre- and post-ULFT water use comparisons comes from monthly (or bimonthly) water meter observations made by a water agency for billing purposes. Water use recorded at the meter reflects a variety of end uses, and toilet water use accounts for just a fraction of total consumption. This complicates the water savings evaluation in that the analysis must control for other factors that may influence water use at the meter.

Collected information included meter reading dates and meter reads for all meters associated with each of our identified CII ULFT sites. Billing cycles were both monthly and bimonthly and spanned 1991 to 1996.

2.5 WEATHER DATA

Weather is a non-ULFT factor that can significantly influence water consumption. Outdoor landscape irrigation can be a major weather-sensitive water end use in the CII sector. Irrigation needs increase with dry, hot conditions and decrease with wet, cool conditions. In addition, weather can potentially influence other water end uses such as cooling processes and water use determinants such as customer visitation. Hence, we need to control for weather in our analysis to more precisely identify ULFT water savings.

We obtained daily weather data for 1991 to 1996 from both California Irrigation Management Information System (CIMIS) and National Oceanic and Atmospheric Administration (NOAA) stations. Weather parameters included evapotranspiration and precipitation. For each water agency, we collected evapotranspiration data from the most representative CIMIS station as listed in Table 2-7. For precipitation, which is known to be more spatially variable, we averaged daily observations from both CIMIS and NOAA stations, when possible, as also listed in Table 2-7.

To quantify how weather varies over time and among agencies, we developed a net irrigation requirement (NIR) variable. NIR equals evapotranspiration minus effective rainfall. Effective rainfall is less than actual rainfall because some rain is lost to runoff or percolates past the root zone of irrigated vegetation. The effectiveness of rainfall to offset evapotranspiration is dependent on the duration, frequency, and intensity of rainfall, soil infiltration rates, and soil storage capacity. In addition, irrigated landscape plant material, particularly turf, is often grown under relatively high soil moisture levels. This implies that only a portion of soil storage is available to absorb the rain that occurs. To calculate effective rainfall we used a daily water balance simulation that considers daily rainfall, soil storage capacity, and daily evapotranspiration. The annual average NIR among the agencies is similar. This is partly a reflection of the coastal location of all 10 participating agencies. A more detailed discussion of the development of the NIR variable is presented in Appendix B.

Table 2-7
Weather Stations and Net Irrigation Requirement (NIR) by Agency

Agency	CIMIS Station	NOAA Station	Annual NIR (inches) 1992-1996
Anaheim	Pomona	†	43
San Diego	San Diego	San Diego WSO	38
SDCWA	San Diego	San Diego WSO	38
Santa Monica	Santa Monica/Long Beach	Santa Monica Pier	40
Santa Barbara	Goleta/Santa Barbara	Santa Barbara	39
SLO	San Luis Obispo	SLO Polytechnic	44
Ventura	Santa Paula/Port Hueneme	†	37
EBMUD	San Jose	SF-Mission	43
Marin MWD	Novato	San Rafael	39
San Francisco	San Jose	SF-Mission	43

Note: NIR = evapotranspiration minus effective rainfall.
†Rainfall data were collected from the CIMIS station only for this agency.

So as not to blur the time matching of water consumption and NIR in the modeling process, we summed daily observations of NIR to exactly match the billing period for each water use observation for each site. Since different customers have different meter read periods, we matched daily weather data individually, by customer, to fit each customer's meter read periods. For example, if a given read period for a particular customer was March 10 through May 12, then we computed weather statistics relevant to that customer for the exact same period of time. After daily weather data were aggregated to match customer meter read cycles, both billing and weather data were adjusted to coincide with calendar months. Since different customers have different meter read cycles, this step is necessary to assure that we can compare water use across different customers for equivalent periods of time.

2.6 WATER AND SEWER PRICE DATA

As the price of a commodity rises, the quantity demanded by consumers tends to decrease. This is the so-called first law of demand in economic theory. Research has consistently shown water to be subject to this law. However, research has not been consistent in quantifying the sensitivity of customers to price, especially in the CII sector. Hence, while we know water use declines with increasing price, we have little basis to know by how much.

Because significant changes in water prices, and sewer prices that are linked to water consumption, can influence water consumption, we need to account for such changes in our modeling of ULFT savings. If a ULFT retrofit occurred at the same time as a major price increase, for example, then the combined water savings of the two events would be wrongly ascribed only to the ULFT if the price event was ignored.

We investigated water and sewer price changes within a water agency over the time period (1991 to 1996). We are not concerned with price differences among water agencies, since the modeling approach we use (explained in Section 2.9) controls for differences across agencies and facilities. We are concerned only with controlling for the impact of price changes at a specific agency over time.

Appendix C contains the water and sewer price histories of the participating water agencies. Our approach is to adjust the nominal prices for inflation and then identify "significant" real price changes for each agency, i.e., a simple change in a flat price, a change in rate structure, or a change in price for various blocks. The identified changes are shown in Table 2-8. We then created a separate indicator variable for each of these price changes for use in testing whether each one had a statistically significant impact on water use. Our exploration of the effect of price changes in the modeling of water savings is described in Section 2.9.[10]

10. It is possible to construct a continuous price variable to control for price effects. There are two major difficulties, however, with this course. First, the water agencies principally involved (Santa Monica, Santa Barbara, and Marin) have block rates that complicate identifying the effective "price signal" (e.g., average price, marginal price, other). In addition, block rates greatly complicate the estimation process because of the simultaneous relationship between water and price (i.e., low water users face low prices and large users face high prices). These complications lead us to use binary variables to account, at least crudely, for the price structure changes. In a rigorous price elasticity study, we would have selected different water agencies, customers, and models to more precisely quantify how price impacts water demand.

Table 2-8
Significant Price or Rate Structure Changes

Water Agency	Month/Year
Santa Monica	4/92
Santa Monica	7/96
Santa Barbara	5/91
Santa Barbara	10/91
Santa Barbara	4/93
Santa Barbara	9/95
Marin Municipal Water District	5/91
Marin Municipal Water District	1/92
Marin Municipal Water District	9/92
Marin Municipal Water District	7/93

2.7 NON-ULFT WATER CONSERVATION MEASURE DATA

Some of the CII sites in the ULFT database installed additional water conservation measures (e.g., urinal retrofits and low-flow showerhead installations) during the time period of our analysis. For example, several hotels that installed ULFTs also installed low-flow showerheads.

The inclusion of facilities that installed multiple conservation measures would confound the estimation of water savings attributable to any specific end use. This is because it is difficult, if not impossible, to disentangle the effects of multiple measures when the timing of their installation is similar.[11] For this reason, we removed 18 sites (4 schools in Anaheim and 14 hotels/motels in East Bay MUD[12]) from the CII sites used in our analysis.

11. One could avoid this entanglement by employing end-use metering.

12. The East Bay MUD sites are also not traditional hotel/motels but low-income temporary housing.

2.8 TELEPHONE SURVEY DATA

To augment our knowledge of the CII ULFT sites, the project included resources to survey 450 sites via telephone interview. The survey was used to verify water agency ULFT tracking data and to learn more about a subsample of sites. The survey instrument is shown in Appendix D.

2.8.1 Sample Selection

How should the 450 sites to be interviewed be selected out of the 1,370 candidate CII ULFT sites? A number of guidelines played a role in our decision, including the following:

- Select sites with known contact names and phone numbers. This information expedites the survey process and increases response rates and reliability of results.
- Obtain a balance of sites among the CII market segments.
- Obtain a geographic balance of sites across southern, central, and northern California. An effort was made to over-sample slightly from central and northern California, in order to modestly increase the sizes of these smaller regional strata in the overall analysis sample.[13]
- Select sites to maximize the likelihood of obtaining statistically significant results from the billing analysis. To quantify this likelihood, we divided total annual water use by the number of toilets at each site to identify sites where toilet water use is likely to be a larger part of total water use than at other sites.

The first factor served as a constraint and limited our candidate pool to 776 sites. The last three factors served as competing objectives in the selection process. We used our judgment to maximize each objective with minimal sacrifice to the other objectives. In addition, because of survey refusals and inabilities to reach some contacts, we anticipated that (under standard response rates) the completion of 450 surveys would perhaps require an attempted census of all those sites with known contact names and phone numbers.

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13. Despite the attempt to over-sample slightly from central and northern California, the final stratification of completed surveys by region (as shown in Table 2-10) turned out to be very close to the stratification of the population of ULFT sites by region (as shown in Table 2-3). Specifically, each region's proportion of the total number of completed surveys turned out to be within plus or minus 2 percentage points of that region's proportion of total ULFT sites. As a result, the final sample closely mirrored the larger population and a sample weighting approach was not necessary.

2.8.2 Telephone Survey Content

The telephone survey had three specific purposes:

- verify/augment water agency ULFT tracking data
- identify potential non-ULFT water related changes at site over time
- elicit customer satisfaction with ULFTs.

Each survey question was carefully designed to meet one of the above purposes. To obtain information necessary to verify and augment the water agency ULFT tracking data, specific questions addressed:

- the most appropriate contact person to respond to the survey
- verification of the site location and the primary business type of the establishment
- the number, type (i.e., tank versus flush valve), and date of the ULFT installations
- the total number of toilets at the location
- the size of the facility, number of employees, operating hours, guest rooms (for hotel establishments), and students (for school establishments)
- age of the facility
- the presence of any outdoor water use.

Potential non-ULFT water related changes over time were identified for each site by asking each respondent to identify the date and type (i.e., increases or decreases) of the following changes:

- size of the facility (square footage)
- size or type of landscape irrigation system
- number of female employees and total employees
- nonemployee use of bathroom facilities
- operating hours
- number of guest rooms (for hotel establishments) and number of students (for school establishments)

▸ other changes such as changes in efficiency levels of urinals, showerheads, or aerators, and changes in number of visitors or production processes.

Finally, to elicit customer satisfaction with ULFTs, respondents were asked to rate, on a scale of 1 to 5, their overall satisfaction with the performance of the ULFTs. Follow-up questions were then asked to assess the reasons for customer satisfaction/dissatisfaction.

2.8.3 Telephone Survey Results

The telephone surveys were conducted in January and February 1997. A total of 452 surveys were completed with ULFT participants. Table 2-9 displays the final response rate, by region, for the telephone surveys. An overall response rate of 66% was obtained. Excluding the 111 sites in southern California that were not contacted to achieve a better geographic balance, the response rate was 79%.

Table 2-9
Telephone Survey — Final Response Rates

	Northern CA		Central CA		Southern CA		Total	
	Number	%	Number	%	Number	%	Number	%
Starting Sample	132		143		501		776	
Number disconnected[a]	6	4.5	7	4.9	21	4.2	34	4.4
Ineligible[b]	6	4.5	4	2.8	8	1.6	18	2.3
No service address available	0	0.0	0	0.0	42	8.4	42	5.4
Adjusted Sample	120		132		430		682	
Refused	5	4.2	6	4.5	44	10.2	55	8.1
Unable to contact after at least 7 attempts	31	25.8	26	19.7	7	1.6	64	9.4
Agencies placed on hold (quota reached)	0	0.0	0	0.0	111	25.8	111	16.3
Completed Surveys[c]	84	70.0	100	75.8	268	62.3	452	66.3

a. No phone number found after calling directory assistance.
b. Ineligibles include business/residential phone numbers.
c. Response rate percent computed as number of completed surveys/adjusted sample.
Data collection period: 1/15/97-2/21/97.

A cross-tabulation of the completed surveys by market segment and region is shown in Table 2-10. The majority of surveys, 268, were completed with customers in the southern region. The central and northern regions had 100 and 84 completed surveys, respectively. The office market segment, which contained the largest percentage of sites in the ULFT participant population, also represented the largest proportion of completed surveys, with 139 completes. The retail market segment had the second highest number of completed surveys (66). As the table indicates, each of the 14 market segment subclasses had at least five completed surveys.

Table 2-10
Telephone Survey Completion by Market Segment and Region

Market Segment	Region			Total
	Central CA	Northern CA	Southern CA	
Automotive	3	3	16	22
Food Store	3	8	4	15
Health Care	8	5	14	27
Hotel/Motel	12	1	14	27
Manufacturing	0	1	17	18
Membership	0	3	2	5
Miscellaneous	3	6	16	25
Multiple	1	5	2	8
Office	20	22	97	139
Religious	1	11	27	39
Restaurant	25	8	16	49
Retail	23	9	34	66
School	0	2	5	7
Wholesale	1	0	4	5
Total	100	84	268	452

Finally, Table 2-11 presents the distribution of completed surveys over the 10 water agencies. San Diego represented the agency with the most completed surveys (197), followed by Marin (72) and Santa Monica (66).

Table 2-11
Telephone Survey Completion by Agency

Agency	Number	Percent
Anaheim	1	0.2
East Bay	1	0.2
Marin	72	15.9
San Diego	197	43.6
San Francisco	11	2.4
San Luis	57	12.6
Santa Barbara	40	8.8
Santa Monica	66	14.6
SDCWA	4	0.9
Ventura	3	0.7
Total	452	100.0

2.9 WATER SAVINGS MODELS

This section presents details on the modeling approaches and equation specifications used to estimate the water savings associated with ULFTs. Much of this section contains material that is technical in nature, intended for those readers interested in the modeling details. Some readers may wish to skip this section and proceed directly to the water savings results presented in Section 2.10.

To estimate the water savings associated with ULFTs, we developed water savings billing analysis models. One of the explanatory variables in these models denotes the installation of ULFTs. In simple terms, this variable allows us to measure the post-retrofit change in water consumption at a site. Because water use is influenced by many other variables, however, the calculation of ULFT savings is not simple.

Although there are numerous potential methods to model ULFT savings, one method must ultimately be chosen. In our preliminary analyses, several different modeling approaches and equation specifications were estimated, with the final modeling approach driven by the nature of the data itself. This section describes in detail the modeling approach used to quantify ULFT water savings.

2.9.1 General Model Form

For the estimation of water savings attributable to the installation of ULFTs, data were available both across facilities (i.e., cross-sectional data) and over time (i.e., time-series data). This type of data set is known as "panel" data. For our purposes, panel data have many advantages over data sets that are exclusively cross-sectional or time-series based.

In a panel model to estimate water savings, the dependent variable is the monthly water use for each site, for each month. This kind of model is useful for evaluating the effects of the CII ULFT retrofits, where dates of ULFT installation are distributed over wide time frames. Instead of using a uniform "installation window" across all participating sites, the monthly panel data model uses site-specific installation windows that correspond to the retrofit month for each individual site.

In this analysis, we used a "fixed effects" panel data model, where variation across sites is captured by an intercept term that is unique to each site (the fixed effect).[14] To express the fixed effects panel data model algebraically, let i and t be subscripts for site i and month t, respectively. The general form of the model is:

$$W_{it} = \alpha_i + \beta' \mathbf{x}_{it} + \epsilon_{it} ,$$

where

W_{it}	=	water use for site *i* during time period *t*
α_i	=	constant term for site *i* (fixed effects)
β	=	vector of coefficients

14. Intuitively, one can view the fixed effects formulation as a "differencing model" in which all characteristics of the site that do not change over time and that may influence water use are captured within the site-specific intercept term. This is a desirable approach for the analysis of the installation of water efficiency measures, since it helps to account for confounding differences across sites.

In practice, rather than estimating several hundred unique intercept terms, an equivalent approach that expresses both the dependent and independent variables in terms of deviations from their time-series means is employed for each facility. The resulting estimated coefficients from this "deviation from the mean" approach are equal to the coefficients found by having customer-specific intercept terms.

Panel data models that incorporated "time effects" as well as fixed effects were also attempted. The time effect refers to the assumption that there are differences over time, but constant across facilities, that can be captured by month-specific intercept terms. The models incorporating both fixed and time effects produced similar results to the fixed effects models ultimately estimated for this analysis.

$\mathbf{x}_{it}$ = vector of variables that influence water use (including indicator variables denoting ULFT installation)

ϵ_{it} = error term.

This model implies, in the context of the CII ULFT retrofits, that differences across sites in characteristics that determine whole-premise water use, such as number of employees, number of visitors, and operating hours, are captured in the site-specific constant term α_i. This term, which is known as the *individual effect* of each cross-sectional unit, is constant over time. Therefore, the only variables included in the vector $\mathbf{x}$ are those that change over time, since the effect of variables that do not change over time is captured by α_i. Examples of variables that may change over time, and which therefore may be included in the vector $\mathbf{x}$, are weather variables, variables indicating seasonality, and indicator variables denoting *changes* at a particular site in key operating and water use related characteristics, such as a significant change in the number of employees, number of visitors, or hours of operation. If other (non-ULFT) water conservation measures are installed at a particular site, then that also represents a *change* that may affect whole-premise water use and which should be accounted for through the inclusion of a variable in the $\mathbf{x}$ vector.

2.9.2 Model Specification

We estimated fixed effects models separately for each of the 14 market segments. In each model, the installation window was defined for each site as the calendar months when ULFTs were installed. We removed from the analysis those months in which installation took place, so that clean pre- and post-installation months remained for each site for inclusion in the regression.

The dependent variable in each model was the site's monthly water use, in hundreds of cubic feet (ccf). For the independent variables, we offer below a general description of (1) a set of "core" variables that were included in each of the market segment regressions and (2) the types of additional independent variables that were tested in preliminary regression analyses and retained in a particular market segment model if they added explanatory power.

The following "core" independent variables were included in each of the market-segment-specific final regression models:

- An indicator variable set equal to the number of ULFT retrofits installed at the site (= 1, 2, 3, etc.). This variable takes on a value of zero for all months before ULFT installation. The estimated coefficient on this variable denotes mean water savings per ULFT retrofit in ccf per month. For the final estimates of savings presented in the next section, these were converted to units of gallons per day.

- NIR, by month and site location. As explained in Section 2.5, NIR equals evapotranspiration minus effective rainfall.

- Twelve interaction variables that capture the effects of seasonality on water use by region (i.e., north, central, and south). A 0-1 indicator variable for each region (i.e., a variable equal to one if the facility is located in the region, zero otherwise) was interacted with one of four seasonal harmonic variables. Two of these variables, known as the first-order sine and cosine terms, are based on a 12-month harmonic pattern of seasonality in water use. The other two variables, which are termed the second-order sine and cosine terms, are based on a 6-month harmonic pattern of seasonality in water use.

- A time trend variable designed to capture the effects of linear trends that may have occurred over time but that are not well measured by the survey data. This could include trends in business activity or relative prices that would affect the demand for water use.

Next, from the telephone survey data, we were able to construct variables denoting facility-specific *changes over time* in site or operating characteristics. Survey variables that added explanatory power to one or more models included:

- change in facility operating hours
- change in number of visitors at facility
- change in total number of employees
- change in gender composition of employees
- change in production process
- extended interruptions in water service
- occurrence of major water leaks
- change in number of faucet aerators or showerheads in facility
- change in efficiency level of urinals
- changes to size or type of irrigation system
- other changes at facility that could affect water use.[15]

2.9.3 Model Estimation and Diagnostics

Although the fixed effects model corrects for the fact that different sites have different levels of average water use, the variance of the unexplained portion of water use across sites (i.e., the error term) is not corrected automatically by this approach. The situation where the variance of the

15. Binary indicator variables for the significant price changes shown in Table 2-8 were also included in preliminary rounds of regression analysis. The results indicated that few of the price change variables were statistically significant, and their inclusion did not have a significant effect on the ULFT savings estimates. For these reasons, price change indicator variables were not included in our final models.

error term is not constant across observations (contrary to a basic assumption of the linear regression model) is termed heteroskedasticity. This condition generally arises in cross-sectional models when the scale of the dependent variable and the explanatory power of the model tend to vary across observations, a situation that is likely to occur when investigating water use across a diverse sample of CII customers. Since it is reasonable to expect that this may be an issue for the CII ULFT retrofit data, we included a correction for heteroskedasticity in each of the market segment regression models.[16]

Another statistical issue that is similar to heteroskedasticity is that of autocorrelation. Autocorrelation is the situation where the error terms for each customer are correlated over time. As is the case for heteroskedasticity, autocorrelation results in least squares estimates that are unbiased. However, the variance of these estimates will be incorrect, which results in incorrect hypothesis testing. We included a correction for first-order autocorrelation in each of the market-segment-specific models.[17]

Finally, we conducted a battery of diagnostic exercises designed to test the stability of the regression models. Variance inflation factors (VIFs), which measure the strength of interrelationships among the independent variables in the model, were examined to identify potential multicollinearity problems. Studentized residuals and DFFITS statistics were used to identify observations that could either be considered outliers (observations that are not well explained by the regression model) or "leverage" points that exert a significant amount of influence on the model results. Both methods, studentized residuals and DFFITS, were used in preliminary regressions and generated similar results. The final diagnostic used the studentized residual because fewer observations were ultimately removed from the analyses using this technique.

Examination of the value of the studentized residual is an approach that is commonly used in regression diagnostics.[18] For any given observation, the value of the *residual* is equal to the difference between the actual (or observed) value of the dependent variable and the predicted (or fitted) value of the dependent variable. For the ULFT water savings models, the value of the

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16. The correction for heteroskedasticity involves using a generalized least squares (GLS) model that explicitly incorporates the covariance matrix of the error terms through the use of weighted least squares where each observation is weighted by the inverse of the standard deviation of its error term. This was accomplished by first estimating the least squares model to obtain an estimate of the variance of the error term for each observation, and then estimating a GLS model where the weights were derived from the estimated variance.

17. The correction for autocorrelation involves a two-step procedure where the coefficient of the lagged error term is first estimated and then used in a second-round GLS model.

18. A good discussion of regression diagnostics and studentized residuals is provided in Belsley, D.A., E. Kuh, and R.E. Welsch, 1980, *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity*, New York, John Wiley.

residual for a given observation equals the difference between that facility's actual water use for the month and the water use that is predicted by the regression model. The *studentized residual* is equal to the residual weighted by its standard deviation. This weighting, or standardization, of the residual yields a statistic that provides a better indication of outlier observations than does the raw residual.

Observations with large studentized residuals may be considered model outliers. We eliminated from the final models those observations (particular months for specific facilities) that displayed studentized residuals greater than 6 in absolute value. The percentage of observations identified as model outliers and subsequently removed from the analysis ranged from 0% to 0.7% for the market-segment-specific regression models.

2.10 WATER SAVINGS ESTIMATES

This section presents the estimates of water savings, per installed ULFT, that were produced by the billing analysis models. The detailed model outputs, which show the estimated coefficients for all explanatory variables plus regression statistics for each market segment model, are included in Appendix E. The independent variable t-statistics shown in the tables in Appendix E were calculated by applying the degrees of freedom adjustment appropriate for panel models. Statistically significant savings were estimated for all but 2 (schools and membership facilities) of the 14 market segments.

As described in the section above, the units of the water use billing data were ccf per month. The savings estimates produced by the models thus were in these same units. We converted the savings estimates to units of gallons per day (gpd) per ULFT retrofit. The resulting estimates of water savings per ULFT are shown in Table 2-12.

Table 2-12 indicates a number of points regarding water savings from ULFT retrofits, which we summarize briefly here. With only two exceptions, the point estimates of savings are statistically significant and reasonably consistent across market segments. The range of estimates is from 16 gpd to 57 gpd per ULFT installed. Most of the estimates are relatively precise, as indicated by the 90% confidence intervals shown in the table. In fact, taken as a whole, the savings estimates are strikingly and unexpectedly precise. This is especially the case given that the estimates are generated by analysis of whole-premise water use for CII facilities, a number of which have very high baseline water use relative to expected ULFT savings.

As mentioned earlier, statistically significant point estimates of savings could not be obtained for two market segments: schools and membership facilities. There are several possible reasons for this result. First, the regression samples based on the telephone survey samples contained very few

Table 2-12
Savings per ULFT Installation by Market Segment

Market Segment	Savings per Installed ULFT (gpd)[a]
Automotive	36 (22-50)
Food Store	48 (37-59)
Health Care	21 (13-28)
Hotel/Motel	16 (11-20)
Manufacturing	23 (15-32)
Membership	N.S.[b]
Miscellaneous	17 (11-23)
Multiple Use	29 (14-45)
Office	20 (17-23)
Religious	28 (20-37)
Restaurant	47 (36-58)
Retail	37 (33-42)
School	N.S.[b]
Wholesale	57 (19-94)

a. 90% confidence interval shown in parentheses.
b. N.S. = Not Significant. Denotes that statistically significant savings estimates could not be obtained.

school and membership facilities, seven and five, respectively.[19] Second, the majority of schools and membership facilities in our sample have irrigation usage that is not separately metered. A significant amount of irrigation use would make it difficult to isolate ULFT savings from the whole-premise billing data.

19. Interestingly, models estimated for these two market segments that used the entire population of participants (rather than just those with survey data available) produced insignificant savings estimates as well. These models were based on samples of 23 schools and 13 membership facilities.

The schools in our sample had the largest average pre-installation (baseline) water use (5,175 gpd) of any of the 14 market segments. This average baseline usage is roughly an order of magnitude higher than that for several other market segments (e.g., average baseline usage within the sample was 675 gpd for offices and 600 gpd for retail). This high average baseline water use is largely driven by one school, Magnolia High School (in Anaheim). The rest of the schools in our sample (i.e., Waldorf School, Montessori School, Childhood Enrichment Center, Pluralistic Schools Inc., Circle of Children Preschool, and Berkely Unified School District) appear to be much smaller preschools and specialty schools. These smaller facilities tend to have fewer ULFTs that may be used less often than ULFTs in typical elementary or high schools. This characteristic of the sample, combined with the fact that ULFTs in schools are probably not used year-round, may also complicate the analysis.

For the membership market segment, inspection of the input data shows that the five membership facilities included in the telephone survey sample consisted of a country club, a swim club, a woman's club, a boy's club, and the SF Marathons facility. Although one would expect that these kinds of facilities would display relatively high values of visitors per day and flushes per day per toilet, there is likely a significant amount of additional water usage as well (e.g., swimming pools, hot tubs, showers). This may also make it difficult to detect ULFT savings from the billing data.

The fact that statistically significant ULFT savings could not be estimated for schools and memberships does not necessarily mean that ULFTs generate little or no savings in these facility types. Rather, the limitations discussed above prohibited us from detecting savings with an appropriate level of statistical confidence. Thus, these two market segments would be good candidates for a secondary analysis that incorporates larger, more representative samples.

For the 12 market segments in which statistically significant estimates were obtained, the largest point estimates of savings were found in wholesale facilities, with 57 gpd. However, note that the confidence interval about the point estimate for wholesale is fairly wide, indicating a fair degree of uncertainty regarding true savings in this sector (where the sample consisted of only five sites). Food stores and restaurants had the second and third highest savings, with 48 gpd and 47 gpd, respectively. The estimate for both food stores and restaurants was quite precise, with t-values slightly over 7 and relatively narrow confidence intervals about the point estimates.

The hotel/motel and miscellaneous market segments had the lowest estimates of savings per ULFT (16 and 17 gpd, respectively). Interestingly, again, hotel/motels had the second highest mean baseline whole-premise water usage, just slightly less than schools. Again, it may be that it is difficult to detect savings per ULFT through a billing analysis when whole-premise use is exceptionally high. Having said this, however, the savings estimates for these two market segments are statistically significant and relatively precise, with t-values of 5.6 for hotel/motel and 4.6 for miscellaneous.

The largest market segments in the participant population are office and retail. The point estimates of savings for these facility types are 20 gpd and 37 gpd, respectively. The estimates for both of these subcategories are quite precise. The t-value of the estimate for offices is 12.3, with the 90% confidence interval for savings extending from 17 gpd to 23 gpd. For retail, the t-value is 13.0 and the 90% confidence interval extends from 33 gpd to 42 gpd. These are excellent results from the standpoint of precision in estimation.

To examine any regional differences in ULFT savings estimates, the market-segment-specific regression models were also estimated to include separate ULFT retrofit variables (described in Section 2.9.2) for each of the three regions (i.e., north, central, and south). Because the majority of market segments have a relatively small number of facilities within each region, the resulting savings estimates by region vary within market segments but are often not very significant. The results of this exercise suggest that there are no clear regional differences in ULFT savings. That is, it does not appear as though one region as a whole has significantly more or less savings associated with it when compared to the other two regions.

Finally, to validate the results presented in Table 2-12, which are based on samples of participants from whom survey data were collected, market-segment-specific regression models were estimated over the entire population of ULFT participants, not just those from whom we obtained telephone survey data. Models estimated over all participants have the advantage of incorporating a larger number of facilities into the analysis; however, these models have the disadvantage of not incorporating important facility-specific information collected in the telephone surveys.

In general, the results of the models estimated over all participants were similar to those reported above. For most market segments, the 90% confidence interval for the savings estimates generated by the population models overlaps the 90% confidence interval for the estimates derived from the survey sample models. The precision of the estimates generated by the population models was also broadly similar to the survey sample models. In particular, the savings estimates from the population models were more precise (as indicated by the t-statistic) for about half of the market segments and less precise for about half of the market segments. This secondary analysis of the entire population of participants lends support to the findings reported in this study for the surveyed sample of participants.

CHAPTER 3
TOILET COUNT CENSUS

The second major objective of this project is to develop a method for quantifying the number of CII toilets within a given water agency's service territory. Obtaining this information can assist water planners in establishing long-term ULFT replacement targets. In addition, when combined with per ULFT water savings estimates, this information can be used to calculate the overall potential and target CII ULFT water savings for an agency.

The toilet count method is based on the following:

- *Covariate Identification.* The basic strategy is to identify a high correlation between number of toilets at a CII site and some other data parameter such as building square footage or number of employees. For the toilet count method to be practical, information about the identified covariate must be readily accessible by water agency planners.

- *Market Segmentation.* Because of their heterogeneity, CII sites are segmented into more homogeneous subgroupings or market segments. This allows for picking and choosing covariates that best represent a particular segment. It also allows for a more customized approach in accounting for different CII customer mixes for individual water agency service areas. The segmentation classification used with this task may differ from the segmentation used in the water saving estimation task described in Chapter 2.

- *No Toilet-Type Differentiation.* The method does not address differences in the types of toilets (e.g., tank versus flushometer or water efficiency), just the total toilet count.

Based on these characteristics, we developed a toilet count method using a variety of inputs. This chapter describes the derivation of the method, its assumptions, and its application to water agencies in California.

3.1 TOILET COUNT METHOD

This section describes the basic method used to estimate the number of CII toilets within a given water agency. To maintain simplicity, we developed a single variable approach as follows:

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$$\text{TOILETS}_i = \text{DRIVER}_i \,/\, \text{COEFFICIENT}_i, \qquad (3\text{-}1)$$

where

TOILETS_i	=	number of toilets in market segment i
DRIVER_i	=	data driver (covariate) in market segment i
COEFFICIENT_i	=	drivers per toilet coefficient in market segment i.

The data driver can be some parameter such as number of employees or building square footage. The coefficient correlates the driver to number of toilets. For example, if the driver is 5,000 employees and the coefficient is 10 employees per toilet, then the number of toilets would be 500. A different driver and coefficient can be selected for each market segment. The summation of TOILETS_i over all market segments i equals the total number of CII toilets for a given water agency.

3.2 COVARIATE IDENTIFICATION

We used three sources of information in selecting the most appropriate data drivers and their corresponding coefficients. They include:

- building and plumbing codes
- MWD CII audit database
- CUWCC telephone survey database.

3.2.1 Building and Plumbing Codes

Model codes specify the minimum number of toilets required to obtain a building permit. Number of employees, building size, and type of use are factors typically considered by codes in determining the minimum number of toilets. Because of strict enforcement, the codes serve as a good source of information in determining the lower bound of number of toilets.

Table 3-1 summarizes how selected data drivers affect the minimum number of toilets required within 11 major market segments based on information in the codes. This summary is based on the 1995 California Building Standards Code (Title 24 of the California Code of Regulations), which incorporates by reference the 1994 Edition of the Uniform Plumbing Code published by the International Association of Plumbing and Mechanical Officials, and the 1994 Edition of the Uniform Building Code published by the International Conference of Building Officials, together with California Amendments.[1]

1. See Appendix F regarding background on the codes.

Table 3-1
Building and Plumbing Code Summary

CII Market Segment	SIC Code	Data Driver	Driver Range	Toilets at Upper Range	Drivers per Toilet in Range
Commercial					
1. Assembly Places		Employees	1 to 30	12.0	2.5
- Theatres, Auditoriums	783		31 to 60	18.3	4.8
			61 to 70	19.7	7.1
			71 to 110	24.3	8.6
			>110		10.9
2. Eating and Drinking Places	58	Employees	1 to 15	2	7.5
			16 to 45	4	15.0
			46 to 90	7	15.0
			>90		30.0
3. Hotels/Motels	70 (not 703)	Guest rooms	None	N.A.	1.0
4. Offices		Employees	1 to 30	2.75	10.9
- Finance, Insurance, Real Estate	60-67		31 to 70	6.75	10.0
- Business Services	73		71 to 110	9.75	13.3
- Legal Services	81		111 to 400	24.25	20.0
- Membership Organ.	86 (not 866)		401 to 800	38.25	28.6
- Engineering and Management	87-89		>800		34.1
5. Retail/Wholesale		Employees	1 to 30	4	7.5
- Wholesale	50-51		31 to 70	7	13.3
- Retail	52-57, 59		71 to 110	9	20.0
- Personal Services	72		101 to 200	13	25.0
- Auto & Misc. Repair	75, 76		201 to 800	32	31.6
			>800		34.1
Industrial					
6. Industrial	20-39	Employees	1 to 10	1	10.0
			11 to 25	2	15.0
			26 to 100	5	25.0
			>100		30.0
Institutional					
7. Churches	866	Employees	None	N.A.	2.2
8. Education	82	Students			
- Primary School			None	N.A.	27.5
- Other			None	N.A.	35
9. Government	90-98	Employees	1 to 30	3.3	9.0
			30 to 70	8.1	8.4
			71 to 110	11.9	10.6
			>110		15.4
10. Health Services	80	Employees	1 to 30	7.0	4.3
- Hospitals			30 to 70	16.7	4.1
- Clinics			71 to 110	25.3	4.6
			>110		5.2

Table 3-1 (cont.)
Building and Plumbing Code Summary

CII Market Segment	SIC CODE	Data Driver	Driver Range	Toilets at Upper Range	Drivers per Toilet in Range
11. Other	All codes not listed elsewhere	Employees	1 to 30	2	15.0
			30 to 70	5	13.3
			71 to 110	7	20.0
			>110		40.0

The selected data driver for hotels/motels is number of guest rooms, for schools it is number of students, and for all other market segments it is number of employees. It is also possible to use building square footage instead of employees in some cases. Number of employees, however, is easier to access and query within the database sources we identified.

For each market segment, the minimum number of toilets is typically based on both an employee component and a visitor component. The employee component is relatively constant over all market segments. The visitor component, in contrast, varies widely. This is logical given that office buildings, restaurants, and industrial sites inherently have different visitation rates.

Another significant observation is that the number of employees per toilet increases with larger sites. There are apparent economies of scale involved with installing toilets. In office buildings, for example, buildings with fewer than 70 employees have a coefficient of about 10 employees per toilet. In buildings with 110 to 400 employees, the incremental number of employees per toilet is 20. Hence, site size is important. In most cases, *we cannot assume that a single coefficient can accurately represent an entire market segment.*

There are several factors complicating the use of codes for our purpose. They are:

- ***Theoretical Employees.*** The employee factors used in the plumbing codes are based on exit capacity requirements (maximum employees based of fire exit constraints). The actual number of employees at a site can be far less.

- ***Toilet Minimums.*** Codes identify toilet minimums. It is possible that actual number of toilets in the field may be higher.

- *Code Changes over Time.* Our review of the codes over the last 30 years indicates that there have been some slight changes. In general, the codes have become more specific with respect to market segment.

- *Americans with Disabilities Act (ADA) of 1992.* The ADA's requirements are geared toward making toilet facilities more accessible to people with disabilities. Because the ADA requirements are retroactive to most existing facilities, some design modifications for accessibility have resulted in the removal of one existing toilet stall to expand another stall so that it is accessible to people with disabilities. This "2 for 1" conversion is not a requirement, but it has been anecdotally reported. It should also be noted that compliance with respect to existing facilities has not been universal nor is it policed by state officials.

- *Urinals.* The codes allow for urinals to replace toilets in male bathrooms as long as the number of toilets remaining is not less than two-thirds of the minimum number of toilets specified.

All of these factors tend to discourage the blind use of codes in estimating the number of toilets in the CII sector. Real world observations are needed to verify and possibly amend plumbing code coefficients.

3.2.2 MWD CII Audit and CUWCC CII Telephone Databases

To cross-check the plumbing code results with actual observations, we consulted two CII databases. The first was assembled by the MWD. It contains information on 902 CII sites that participated in a water conservation audit (survey) program in southern California. The audits were conducted from 1992 to 1996, with 86% done in the last two years. The database contains site information on SIC code, number of toilets, number of employees, building square footage, number of guest rooms (hotels/motels), and number of students (schools), among other factors. Information was collected during site visits by auditors.

The other database is the CUWCC telephone survey of 452 CII California sites conducted as part of this project as described in Chapter 2. Information collected specifically to assist us with this toilet count validation task included SIC codes, employees, building square footage, guest rooms, and number of students.

Table 3-2 compares the theoretical toilet count estimates derived from the codes as a percentage of the actual number for sites in the MWD and CUWCC databases. This is done for each market segment. The following observations are derived from this analysis:

- In all market segments except schools, the toilet count derived from the codes is less than the actual number reported in the field. In our sample of 185 office buildings, for example,

Table 3-2
Code-Derived Toilet Estimates Compared with Actual Data

Market Segment	Data Driver	MWD and CUWCC Databases: Number of Sites	MWD and CUWCC Databases: Code-Derived Toilet Estimate as % of Actual Toilets
Commercial			
Assembly Places	Employees	2	46%
Eating and Drinking	Employees	138	77%
Hotels/Motels	Rooms	117	95%
Offices	Employees	185	39%
Retail/Wholesale	Employees	149	81%
Industrial			
Industrial	Employees	132	50%
Institutional			
Education	Students	154	104%
Churches	Employees	26	71%
Government	Employees	23	56%
Health Services	Employees	102	49%
Other	Employees	113	41%

the code-derived toilet estimate is 39% of the actual number. We believe the principal explanation is that actual number of employees is less than number of employees derived via maximum exit requirements at a site. It is also possible that some designers may call for more toilets than required by the codes. Regardless of cause, the understatement of toilets derived by using actual employees with plumbing codes is substantial.

- The school coefficients of 27.5 students per toilet for primary schools and 35 students per toilet for other educational sites closely match reality. In fact, actual student enrollment divided by these coefficients generates only 4% more toilets than those observed at the 153 school sites included in our study.

- For hotels/motels, number of guest rooms is a strong indicator of the number of toilets at a site. Using a one-to-one ratio between rooms and toilets, toilets are underestimated by about 5% in our sample of 117 sites. This is logical given that some additional toilets are typically assigned to either employees or public use.

The conclusion drawn from this analysis is that, except for schools and hotels, we need to recalibrate the code-derived factors. Section 3.3.2 addresses this issue.

3.3 RECOMMENDED DRIVERS AND COEFFICIENTS

What are the best data drivers and coefficients for each market segment? In making our recommendation, we considered the following:

- ***Data Driver Accessibility.*** Preference is given to data drivers that are more accessible to water agency staff.
- ***Data Driver Distribution.*** Because the relationship between a data driver and number of toilets is not necessarily linear, it is important to select data driver sources that can provide detailed information about the statistical distribution of a data driver.
- ***Geographic Resolution.*** Water agency service area boundaries are diverse. Some may coincide with county, city, or other political boundaries. Others may, at least approximately, match up with ZIP codes or U.S. Census designations. In any case, the information source should be flexible and detailed so that the data driver values can be geographically matched to a water agency.
- ***Simplicity.*** Increasing the level of detail may increase accuracy, but it will also increase the complexity of the toilet count calculations. A balance needs to be achieved. Where possible, the toilet count method should be condensed to achieve simplicity when loss of accuracy is minimal.

With these points in mind, we derived a recommended list of data drivers and coefficients for each market segment as described in the next sections.[2]

3.3.1 Data Drivers

Employment

An extensive source of employment information can be obtained via Dun's Direct Access (DDA), a commercial database offered by Dun & Bradstreet. This database can be accessed using DDA software and a modem. The software allows you to organize, filter, print, and download the data

2. We must qualify that the adjustment factors to the codes come from a nonrandom sample of CII sites and hence are not necessarily representative of California CII sites as a whole. However, this information is the best data available at this time.

in a variety of ways. We found it useful for this task because the user can search and identify sites based on detailed SIC codes, geographic area, and employee size.

- *SIC Codes.* A user can make search profiles based on two-, four-, six-, and eight-digit SIC codes. The user can select individual codes from the menu, exclude codes from the menu, or specify a range of codes.
- *Geographic Area.* Search profiles can be based on state, county, Metropolitan Statistical Area, city, ZIP code (three-, five-, or nine-digit), or telephone area code or exchange.
- *Employees.* The number of sites within default or customized employee ranges is available.

DDA can provide results in a spreadsheet format with each row identifying a SIC code and each column an employee range. To use DDA's software, a user needs the following:

- a hard-disk drive with a minimum of 2 MB of available space for the program and additional space for downloading data and creating formatted data files
- a Hayes-compatible modem that can transmit and receive 1200, 2400, or 9600 baud
- MS-DOS 3.0 or higher (this software can also be used with Macintosh systems).

DDA offers technical assistance and can be contacted at 1-800-526-0651. The cost for accessing DDA for this study was about $140 for the data search and a $95 annual subscription fee per license.

Student Enrollment

The California Department of Education provides detailed data on student enrollment by school. For primary and secondary schools, student enrollment files for both public and private schools can be downloaded via the Internet.[3] A water agency will have to individually identify each school within its service territory. Schools are sorted by county and school district to assist in the selection. Post-secondary school enrollments can also be obtained via the Internet.[4] This includes California state and university systems, community colleges, and private institutions.

3. http://www.cde.ca.gov/ftpbranch/retdiv/demo/cbeds_htm_files/main.HTM.

4. http://www.ca.gov/gov/higher.html.

Hotel/Motel Rooms

The 1992 U.S. Census of Service Industries, Subject Series Hotels, Motels, and Other Lodging Places contains information on number of guest rooms.[5] Geographic resolution is restricted to the state and Metropolitan Statistical Area level. This geographic level will be inadequate in most cases for isolating the number of guest rooms. However, from this information one can calculate the local ratio between number of guest rooms and number of hotel/motel establishments. One can then obtain the total number of hotel/motel sites within a water agency service area from Dun and Bradstreet and multiply by the guest room factor. This process will lead to an estimate of the number of hotel/motel guest rooms within a service territory. Unfortunately, the DDA database does not include number of guest rooms as a data field.

3.3.2 Driver Coefficients

The conclusion drawn from Table 3-2 is that we cannot use actual employees with the code standards to accurately estimate CII toilets. Correction factors are required. The question we address is how should the correction factors be developed, especially with respect to the many employee ranges involved.

We investigated this issue by comparing theoretical code toilet count estimates with actual toilet counts within each range and applicable market segment. Table 3-3 shows the results. In reviewing these results, we conclude that the differences observed in toilets are relatively proportional across all ranges. Over the six employee ranges for offices, for example, the understatement ranges between 31% and 54%.

This information also clearly shows that the number of employees per toilet increases with larger sites, as suggested by the plumbing codes. Hence, although it would greatly simplify the process to ignore site size, we do not recommend eliminating the employee ranges because of the great loss of accuracy involved. One exception is with health services. Consolidating the coefficients that range from 4.2 to 4.8 employees per toilet would lead to minimal loss.

After gathering this information, we developed a set of recommended drivers and coefficients as listed in Table 3-4. We proportionally decreased the employees per toilet estimates in each range to reflect the average understatement for that market segment based on the CUWCC and MWD database observations. The items listed in the comments column of the table describe segment-specific adjustments.

5. http://www.census.gov/ftp/pub/mp/www/pub/bus/msbus9d.html.

Table 3-3
Code-Derived Toilet Estimates Compared with Actual Data by Driver Range

CII Market Segment	Data Driver	Driver Range	# of Sites	Drivers per Toilet in Range[1]: Based on Codes	Drivers per Toilet in Range[1]: Based on MWD & CUWCC Databases	Code-Derived Toilet Estimate as % of Actual Toilets
Commercial						
1. Assembly Places[2]	Employees	1 to 30	N.A.	N.A.	N.A.	N.A.
		31 to 60	N.A.	N.A.	N.A.	N.A.
		61 to 70	N.A.	N.A.	N.A.	N.A.
		71 to 110	N.A.	N.A.	N.A.	N.A.
		>110	N.A.	N.A.	N.A.	N.A.
2. Eating and Drinking	Employees	1 to 15	34	4.0	3.3	82%
		16 to 45	57	10.2	6.8	67%
		46 to 90	39	12.1	10.6	88%
		>90	8	15.1	11.0	73%
3. Hotels/Motels	Guest Rooms	None	117	1	0.95	95%
4. Offices	Employees	1 to 30	106	4.5	1.9	42%
		31 to 70	19	10.5	5.1	49%
		71 to 110	13	11.0	4.8	44%
		111 to 400	18	14.8	6.1	42%
		401 to 800	12	19.2	10.3	54%
		>800	15	24.2	7.6	31%
5. Retail/Wholesale	Employees	1 to 30	78	4.2	3.3	78%
		31 to 70	39	9.0	8.4	93%
		71 to 110	19	12.7	10.0	79%
		111 to 200	6	14.1	13.8	98%
		201 to 800	7	17.6	10.9	62%
		>800	0			
Industrial						
6. Industrial	Employees	1 to 10	7	8.3	4.8	58%
		11 to 25	13	9.8	4.7	48%
		26 to 100	41	17.7	8.3	47%
		>100	71	26.0	13.1	50%
Institutional						
7. Churches	Employees	N.A.	53	2.2	1.5	71%
8. Education[3]	Students		154	30.2	31.4	104%
9. Government	Employees	1 to 30	5	9.0	0.9	10%
		30 to 70	5	8.8	4.3	49%
		71 to 110	4	9.1	7.3	81%
		>110	9	14.0	8.0	57%
10. Health Services	Employees	1 to 30	31	4.3	1.0	23%
		30 to 70	19	4.2	1.4	34%
		71 to 110	19	4.3	1.5	35%
		>110	32	4.8	3.1	64%

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Table 3-3 (cont.)
Code-Derived Toilet Estimates Compared with Actual Data by Driver Range

CII Market Segment	Data Driver	Driver Range	# of Sites	Drivers per Toilet in Range: Based on Codes	Drivers per Toilet in Range: Based on MWD & CUWCC Databases	Code-Derived Toilet Estimate as % of Actual Toilets
11. Other	Employees	1 to 30	77	5.9	2.5	43%
		30 to 70	17	10.8	5.9	54%
		71 to 110	6	12.9	4.5	35%
		>110	13	30.6	11.6	38%

1. Please note in each range total employees is divided by total toilets (not range specific).
2. Insufficient observations to analyze assembly places (two).
3. School results based on students and include a combination of elementary and secondary schools.

3.4 TOILET CENSUS CASE STUDY: SAN LUIS OBISPO

To illustrate the procedures involved with the toilet count method, we prepared an example application using the city of San Luis Obispo as a case study. Other water agencies can use this process as a template for conducting their own CII toilet count census.

The first step was to obtain the values of the data drivers. Employment data were extracted from the DDA database. To accommodate all of the varying ranges across all CII market segments and to minimize errors from interpolation between ranges, we defined and retrieved the number of CII sites within 20 different employee count ranges. School enrollment observations for primary and secondary schools were obtained from California Department of Education files downloaded from their Internet site. In addition, we separately accounted for students at a large state college (CalPoly) in San Luis Obispo. The number of guest rooms per hotel/motel establishment was estimated to be 40.3 by review of U.S. Census data for the San Luis Obispo Metropolitan Statistical Area. Given that the DDA database identified 40 hotel/motel establishments in San Luis Obispo, the total number of guest rooms is estimated to be 40.3 × 40, or 1,612. Table 3-5 shows the values of the identified data drivers.

The second step is to organize the data driver coefficients. For each employment range, we calculated the average number of toilets per site based on the recommended driver coefficients listed in Table 3-4 and assuming the number of employees equals the midpoint within each employee range. Because hotels/motels and schools are based on different data drivers, their coefficients are listed under "other" in the last column of Table 3-6.

The third step is to multiply the number of sites within each employee range and CII segment (data from Table 3-5) by the average number of toilets within its corresponding data driver

Table 3-4
Recommended Data Drivers and Coefficients

CII Market Segment	Data Driver	Driver Range	Coefficient: Drivers per Toilet	Comments
Commercial				
1. Assembly Places	Employees	1 to 30 31 to 70 71 to 110 >110	1.2 2.5 3.9 5.0	Coefficients equal 46% of code estimates. Range 31 to 70 condensed.
2. Eating and Drinking	Employees	1 to 15 16 to 90 >90	5.8 11.6 23.1	Coefficients equal 77% of code estimates. Range 16 to 90 condensed.
3. Hotels/Motels	Guest Rooms	All	0.95	1 toilet per room plus 1 per 20 rooms for public use.
4. Offices	Employees	1 to 30 31 to 70 71 to 110 111 to 400 401 to 800 >800	4.3 3.9 5.2 7.8 11.1 13.8	Coefficients equal 39% of code estimates.
5. Retail/Wholesale	Employees	1 to 30 31 to 70 71 to 110 111 to 200 201 to 800 >800	6.1 10.8 16.2 20.3 25.6 27.6	Coefficients equal 81% of code estimates.
Industrial				
6. Industrial	Employees	1 to 10 11 to 25 26 to 100 >100	5.0 7.5 12.5 15.0	Coefficients equal 50% of code estimates.
Institutional				
7. Churches	Employees	All	1.6	Coefficient equal 71% of code estimate.
8. Education	Students	All	27.5 or 35	No adjustment.
9. Government	Employees	1 to 30 30 to 70 71 to 110 >110	5.0 4.7 5.9 8.6	Coefficients equal 56% of code estimates.
10. Health Services	Employees	All	2.3	Coefficient equal 49% of code estimate. All ranges condensed.
11. Other	Employees	1 to 30 30 to 70 71 to 110 >110	6.2 5.5 8.2 16.4	Coefficients equal 41% of code estimates.

Table 3-5
Step 1: CII Sites per Employee Range for City of San Luis Obispo

CII Market Segment	Employees per Site 1-10	11-15	16-20	21-25	26-30	31-45	46-70	71-90	91-100	101-110	111-200	201-400	401-600	601-800	801-1000	1001-2000	2001-3000	3001-4000	4001-5000	5001+	N/A	Total
Assembly Places	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
Eating and Drinking	48	21	12	9	5	9	4	0	0	0	1	1	0	0	0	0	0	0	0	0	7	117
Offices	957	30	18	10	6	15	5	3	1	0	2	2	0	0	0	0	0	0	0	0	9	1,058
Hotels/Motels	21	6	0	3	1	1	2	1	0	0	1	1	0	0	0	0	0	0	0	0	3	1,612
Retail/Wholesale	1,034	35	22	12	9	17	7	4	0	0	3	1	0	0	0	0	0	0	0	0	18	1,162
Industrial	143	18	8	5	6	4	4	5	1	1	4	2	0	0	0	0	0	0	0	0	3	204
Churches	50	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	55
Education — Primary																						3,349
Education — Secondary																						1,653
Education — Higher																						14,107
Government	3	1	1	3	2	4	6	1	0	1	3	1	0	1	0	1	1	0	0	0	4	33
Health Services	254	13	10	3	0	2	2	0	1	0	4	3	1	0	0	0	0	0	0	0	3	296
Other	253	9	10	2	10	9	5	3	4	0	0	3	1	0	0	0	0	0	0	0	16	325
Total Sites	2,512	127	71	45	29	52	30	14	3	2	18	11	1	1	0	1	1	0	0	0	50	2,968

Hotel/Motel total equals number of sites multiplied by 40.3 which is the average number of guest rooms per site based on SLO Metropolitan Statistical Area data.
Education totals reflect number of students, not employees. Totals reflect sites not students.
Data Source: Dun's Direct Access

coefficient cell (data from Table 3-6). The resulting total number of toilets is tabulated in Table 3-7. This method estimates the total number of CII toilets in the city of San Luis Obispo to be 12,170. Given that the total number of sites equals 2,968, the average number of toilets per CII site is 4.1.

Figure 3-1 charts the relative percentage of toilets by market segment. The largest number of toilets are contained within office building (22%) and retail/wholesale (21%) sites. Health services and hotels/motels are the next largest segments, each representing 14% of sites. These four market segments constitute 71% of total toilets.

To test the validity of the toilet count census method, we compared the toilet count results estimated by our method (as shown in Table 3-7) with toilet count estimates made by the San Luis Obispo (SLO) Community Development Department. SLO's toilet estimates were based on building permit applications and their Land Use Inventory program. The toilet totals were calculated before the CUWCC study and were unknown to us until after our estimate was made. The total number of toilets estimated by SLO within their CII sector was 11,200, not including higher education (CalPoly). The comparable CUWCC estimate of the total number of toilets is 11,767. Hence, the toilet count census method estimate is more than the SLO estimate by 567 toilets, or 4.8%. This evidence supports the credibility of the toilet count census method and provides an independent observation to its accuracy.

With respect to testing results by market segment, SLO had toilet count estimates broken out for only five segments, as shown in Table 3-8. Estimates are in close agreement with those derived with the toilet count census method. One exception is with assembly places, although the number of sites (three) included in this market segment is small. SLO made site visits for five other market segments to help verify the toilet count method. SLO staff found that the CUWCC toilet count method closely matched field observations within their sample.

Table 3-6
Step 2: Average Number of Toilets per Site by Employee Range for City of San Luis Obispo

CII Market Segment	Employees per Site																				
	1-10	11-15	16-20	21-25	26-30	31-45	46-70	71-90	91-100	101-110	111-200	201-400	401-600	601-800	801-1000	1001-2000	2001-3000	3001-4000	4001-5000	5001+	N/A	Other
Assembly Places	4.2	10.8	15.0	19.2	23.3	28.2	32.2	43.7	47.5	50.1	60.4	89.4									4.2	
Eating and Drinking	2.0	2.2	2.8	3.3	3.7	4.6	6.3	8.2	9.3	9.7	11.9	18.2									2.0	
Offices	2.0	3.0	4.2	5.3	6.5	9.0	14.2	19.3	22.1	24.1	30.8	49.3	71.2	89.2	105.4	148.9	221.4	293.8	366.3	583.7	2.0	
Hotels/Motels																						0.95
Retail/ Wholesale	2.0	2.1	3.0	3.8	4.6	5.7	7.5	9.3	10.2	10.8	13.3	19.5									2.0	
Industrial	2.0	2.4	3.1	3.7	4.2	5.0	6.6	8.4	9.6	10.4	13.7	23.4	36.7	50.0	63.4	103.4	170.0	236.7	303.4	503.4	2.0	
Churches	2.0	8.1	11.3	14.4	17.5	23.8	36.3	50.3	59.7	65.9											2.0	
Education — Primary																						27.5
Education — Secondary																						35
Education — Higher																						35
Government	2.0	2.6	3.6	4.6	5.6	7.7	12.0	16.3	18.8	20.5	26.6	43.4	66.7	90.0	113.2	183.0	299.3	415.5	531.8	880.7	2.0	
Health Services	2.2	5.7	7.8	10.0	12.2	16.5	25.2	35.0	41.5	45.9	67.6	130.7	217.6	304.6	391.5	652.4	1,087.2	1,522.0	1,956.7		2.2	
Other	2.0	2.1	2.9	3.7	4.5	6.3	9.9	13.4	15.2	16.4	19.8	28.6	40.8	53.0	65.2	101.8	162.8	223.7	531.8	880.7	2.0	

Average number of toilets based on mid-point of employee range. Minimum of 2 toilets at each site (one male and one female).
For example, the calculation for an office with 38 employees (midpoint between 31 and 45) would be: 30/4.3+((31+45)/2-30)/3.9= 9.0 toilets
For the first 30 employees, there are 4.3 employees per toilet as expressed in Table 3-4 which totals 6.98 toilets.
For the next 8 employees, there are 3.9 employees per toilet as expressed in Table 3-4 which totals 2.05. 6.98+2.05=9.0 (rounded)

Table 3-7
Step 3: Total Number of Toilets by Employee Range for City of San Luis Obispo

CII Market Segment	Employees per Site																				Other	Total
	1-10	11-15	16-20	21-25	26-30	31-45	46-70	71-90	91-100	101-110	111-200	201-400	401-600	601-800	801-1000	1001-2000	2001-3000	3001-4000	4001-5000	5001+	N/A		
Assembly Places	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4		13
Eating and Drinking	96	47	34	29	19	41	25	0	0	0	12	18	0	0	0	0	0	0	0	0	14		336
Offices	1,914	91	75	53	39	135	71	58	22	0	62	99	0	0	0	0	0	0	0	0	18		2,637
Hotels/Motels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,697	1,697
Retail/Wholesale	2,068	75	65	45	41	96	53	37	0	0	40	19	0	0	0	0	0	0	0	0	36		2,575
Industrial	286	43	25	19	25	20	27	42	10	10	55	47	0	0	0	0	0	0	0	0	6		614
Churches	100	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4		128
Education — Primary	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	122	122
Education — Secondary	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	47
Education — Higher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	403	403
Government	6	3	4	14	11	31	72	16	0	21	80	43	0	90	0	183	299	0	0	0	8		880
Health Services	552	73	78	30	0	33	50	0	42	0	270	392	218	0	0	0	0	0	0	0	7		1,745
Other	506	19	29	7	45	57	50	40	61	0	0	86	41	0	0	0	0	0	0	0	32		972
Total	5,537	375	310	198	181	413	347	194	134	31	518	704	258	90	0	183	299	0	0	0	129	2,269	12,170

Note: Column entries may not sum to totals due to rounding.
For example, total toilets for offices in the 31 to 45 employee range equals 15 offices (Table 3-5) * 9.0 toilets per office (Table 3-6) = 135 toilets.

Figure 3-1
San Luis Obispo CII Toilet Composition

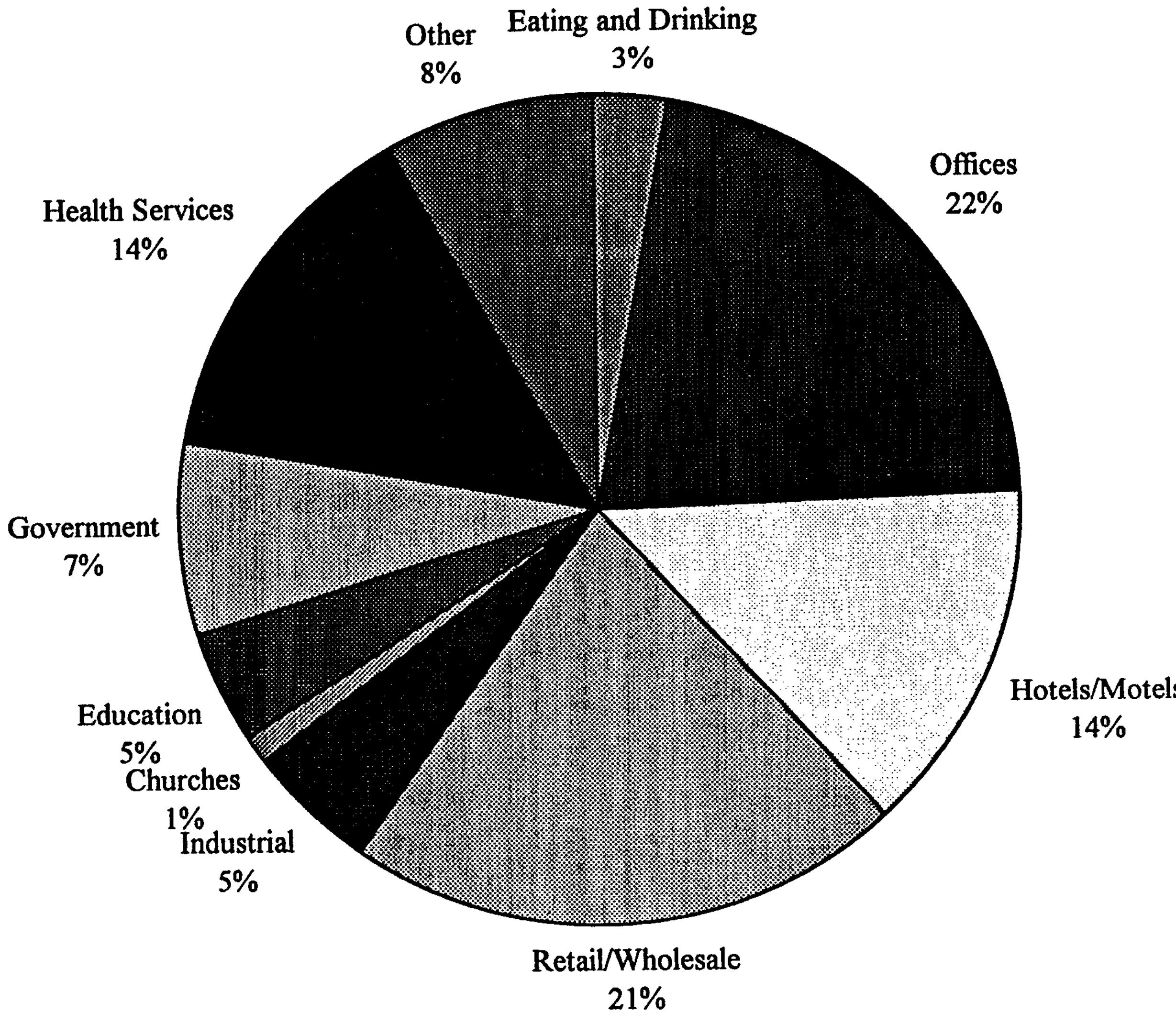

Table 3-8
Toilet Count Verification Results

CII Market Segment	CUWCC Estimated Toilets	SLO Estimated Toilets
Assembly	13	20
Eating and Drinking	336	325
Offices	2,637	2,800
Hotel/Motel	1,697	1,600
Retail/Wholesale	2,575	Not Available
Industrial	614	700
Churches	128	*
Education-Primary	122	*
Education-Secondary	47	*
Government	880	*
Health Services	1,745	*
Other	972	Not Available
Total	11,767	11,200
Education-Higher	403	Not Available

* 14 site visits were conducted at a sample of facilities to test validity of the CUWCC toilet estimates. Samples were in high agreement with toilets per site coefficients shown in Table 3-6.

CHAPTER 4
ADDITIONAL ISSUES

This chapter discusses additional issues raised by our analysis. Section 4.1 recaps the estimates of water savings from ULFT retrofits and discusses the implications of these estimates for targeting the most cost-effective market segments. Section 4.2 describes how water conservation planners can link the market segments derived with the toilet count method to ULFT water savings estimates. Section 4.3 presents our survey findings on the topic of customer satisfaction with the ULFTs. Section 4.4 presents the recommendation that water agencies work together to standardize water conservation program tracking databases. Section 4.5 discusses the advantages and disadvantages of estimating savings through the analysis of whole-premise billing data, and raises the desirability of collecting detailed end-use information in future research efforts.

4.1 ESTIMATES OF SAVINGS AND THEIR IMPLICATIONS FOR TARGETING MARKET SEGMENTS

The water savings estimates produced by this study, ranked from highest to lowest by market segment, are summarized in Table 4-1. As discussed in Chapter 2, most of the point estimates shown are relatively precise.

The water savings estimates shown in Table 4-1 suggest that water conservation planners can improve the cost-effectiveness of their CII ULFT retrofit programs by targeting particular market segments. We draw the following conclusions:

- The best place to install ULFTs is at retail/ wholesale and restaurant sites where average water savings range from 36 to 57 gpd per ULFT. Within the retail market segment, we had sufficient observations to separately identify water savings associated with food stores and automotive (e.g., gas stations) sites, and found the water savings results comparable with other retail establishments.

Table 4-1
Savings per ULFT Installed by Market Segment

Market Segment	Savings (gpd)
Wholesale	57
Food Store	48
Restaurant	47
Retail	37
Automotive	36
Multiple Use	29
Religious	28
Manufacturing	23
Health Care	21
Office	20
Miscellaneous	17
Hotel/Motel	16

With respect to restaurants, we did not make a distinction between fast-food and sit-down, but about 90% of our sample included the sit-down type.

- Religious, manufacturing, health care, and office all provide relatively modest savings in the 20 to 28 gpd range.

- Hotels/motels are the least attractive segment to install ULFTs, with reported savings of only 16 gpd.

Based on toilet count data from the city of San Luis Obispo, about one-quarter of toilets fall into the retail/wholesale/restaurant category. Hence, not only are water savings relatively high for this group, but also a sizable number of toilets exist that would be prime candidates for ULFT installation. The middle group of sites (i.e., religious, manufacturing, health care, and office) contain about one-half of total toilets. Lastly, the hotel/motel segment contains about 15% of toilets.

4.2 LINKING THE TOILET COUNT METHOD WITH WATER SAVINGS

Because water agencies have different mixes of CII customers, a customized analysis will be needed to quantify CII ULFT potential within an agency. To do this, the results of the toilet count method (described in Chapter 3) can be linked to the water savings results (described in Chapter 2). The linkage, however, is not exact. Nevertheless, Table 4-2 shows our best estimate of the water savings by market segment using the toilet count method market segment definitions. We assigned the water savings associated with the "miscellaneous" segment (17 gpd) to assembly places. This is done because this evaluation did not include any assembly place sites, and, hence, we do not have a better basis to make an estimate. We also did not specifically investigate the water savings at government sites. A previous study of 70 sites in San Diego, however, did address this segment. That study showed ULFT water savings for police stations, fire stations,

Table 4-2
Market Segment Link between Toilet Count Method and Water Savings Estimates

Market Segment Defined with Toilet Count Method	ULFT Savings (gpd)
Assembly Places	18
Eating and Drinking	47
Hotels/Motels	16
Offices	20
Retail/Wholesale	37-57
Industrial	23
Churches	28
Education	N.A.
Government	20-117
Health Services	21
Other	18

libraries, and other government facilities to be 20, 28, 76, and 117 gpd per ULFT, respectively. The reader should refer to that study for details.[1]

4.3 ULFT SATISFACTION

This study focused on the overall water savings derived from ULFTs in the field. The study was **not** designed to evaluate the myriad issues surrounding ULFTs such as double flushing, toilet cloggage, or other maintenance issues. It was convenient, however, for us to add an ending question to the telephone survey of 452 sites asking about the respondents general experience with the new ULFTs. One question asked respondents to select, on a scale of 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied," how satisfied they have been with the performance of the ULFT. Table 4-3 shows the frequency of responses and mean ratings.

Table 4-3
Customer ULFT Satisfaction

Market Segment	Observations	Satisfaction Rating (1 = low, 5 = high)					Mean Rating Total
		1	2	3	4	5	
Automotive	22	9%	5%	18%	14%	55%	4
Food Store	15	7%	7%	0%	13%	73%	4.4
Health Care	27	11%	19%	19%	19%	33%	3.4
Hotel/Motel	27	11%	26%	15%	19%	30%	3.3
Manufacturing	17	0%	0%	18%	24%	59%	4.4
Membership	5	0%	0%	0%	80%	20%	4.2
Miscellaneous	25	16%	24%	20%	12%	28%	3.1
Multiple	8	13%	25%	13%	38%	13%	3.1
Office	135	4%	9%	19%	27%	42%	3.9
Religious	39	3%	13%	23%	21%	41%	3.8
Restaurant	46	7%	7%	24%	22%	41%	3.8
Retail	65	6%	2%	23%	25%	45%	4
School	7	14%	0%	14%	43%	29%	3.7
Wholesale	5	0%	40%	40%	0%	20%	3
Total	443	6%	10%	19%	23%	41%	3.8

1. A&N Technical Services, Inc. 1994. *Water Savings From Non-Residential Toilet Retrofits: An Evaluation of the City of San Diego's Public Facilities Retrofit Program*. Metropolitan Water District of Southern California.

The results across all market segments vary moderately. ULFT satisfaction is lowest in the wholesale, miscellaneous, multiple, and hotel/motel segments (ranging from 3.0 to 3.3). ULFT satisfaction is highest in the food store, manufacturing, automotive, and retail segments (ranging from 4.0 to 4.4). The overall average score across all segments is 3.8.

Respondents were allowed to comment on why they gave the satisfaction rating they did. Table 4-4 lists the most common responses. The two most frequent responses identify problems.

Table 4-4
ULFT Satisfaction Comments

Comment	Count	% of Total
Toilets clog	106	23%
Need to double flush	91	20%
They save water	86	19%
No problems	79	17%
Likes the toilets/they work	44	10%
Not enough power/water	15	3%
Needs repairs	14	3%
Need to be cleaned more often/dirtier	12	3%
No opinion one way or the other	10	2%
Sluggish flush	10	2%
Doesn't like toilets	8	2%
Noisy	5	1%
Less maintenance	5	1%
Overflow	4	1%
Leaks	3	1%
Not designed for commercial use	3	1%
No savings	3	1%
No need to double flush	2	0.4%
Poor construction	2	0.4%
Foreign objects do not flush	1	0.2%
Continuously runs	1	0.2%
Toilets too big	1	0.2%
Water splashes on seats	1	0.2%

Apparently, increased maintenance and double flushing are major reasons for ULFT dissatisfaction among some users. The next three most frequent responses are positive, indicating that ULFTs saved water, had no problems, and worked. Overall, 55% provided negative responses regarding ULFTs (e.g., toilets clog or double flush) and 45% provided neutral or positive statements (e.g., save water, no problems, like toilets).

4.4 STANDARDIZATION OF WATER CONSERVATION PROGRAM TRACKING DATA

We strongly recommend that California water agencies standardize some core elements of their CII ULFT program tracking databases. Our experience demonstrated that there is great variation in the type and detail of tracking data currently being collected. Standardizing data fields for future collection would pose, in most cases, little additional cost. In contrast, collecting missing tracking data after the fact can be expensive and perhaps impossible. Hence, a little forethought can go a long way.

Each agency has different immediate needs for its CII ULFT tracking database. For most, it serves as a record for paying ULFT rebate checks. By collecting a standardized set of information, however, a water agency can obtain the following additional benefits:

- ***CII Customer Base Knowledge.*** The database can provide a wealth of knowledge in identifying the number, market sector, size, and location of CII/ULFT customers. This type of marketing information can assist water conservation planners in judging the success of promotional efforts. Or, when combined with the toilet count census method, it can assist in estimating ULFT penetration rates and overall water savings potential. A database could also be integral to the process of targeting the most cost-effective opportunities in a service area. These benefits, and others, can greatly improve project management capabilities.

- ***Exchange of Information.*** Standardizing some core elements of the database can facilitate interagency distribution of information. Perhaps one agency has substantial experience with schools and another with hotels. These agencies can share information to learn and help guide the future direction of their individual programs. In contrast, tracking databases without a market sector field, for example, would be of much less value in comparing and contrasting experiences. Standardized information is also vital in continuing efforts to measure and evaluate the performance of ULFTs in the field.

- ***Water Savings Measurements.*** Standardizing data would greatly assist the ease and accuracy of data collected for empirical water savings investigations.

Each water agency may have customized needs for its tracking data. However, we recommend that all agencies collect information on a minimum set of the following core fields:

- customer name
- site address
- account/meter number(s)
- CII market segment (SIC code)
- contact name
- contact phone number
- total toilets at site
- ULFT retrofit date(s)
- number of ULFT retrofits
- ULFT type
- pre-retrofit toilet type.

4.5 ESTIMATING ULFT SAVINGS THROUGH BILLING DATA ANALYSIS

The approach of estimating water savings through billing data analysis has both strengths and weaknesses. The major advantage of a billing analysis is that it is comprehensive with respect to total water savings. ULFT water savings are a function of many variables, including:

- Water efficiency of pre-retrofit toilet (gpf).
- Water efficiency of ULFT (gpf).
- Flush counts (average flushes per day).
- Extent of double flushing.
- Extent of toilet leakage.
- Toilet blockages or other maintenance problems (e.g., water savings are high when toilet does not work).
- Psychological impact that lowering water use may have on other water end uses. For example, ULFT water savings may encourage other water conservation activities or they may encourage other water uses (e.g., an increase in landscaping).

It is difficult to precisely evaluate these complicating factors individually. A billing data analysis, however, examines total whole-premise water use and thus can provide a good estimate of net water savings, i.e., savings after accounting for the factors above. Another advantage of a billing data analysis is that it is relatively inexpensive to collect a large data set. From a statistical vantage, more data are better since this affords the opportunity for improved precision in estimation as well as a higher degree of stratification and representation.

A weakness of using billing data is that the water associated with each end-use water application (e.g., toilet) cannot be directly specified. End-use information would be valuable and necessary to assess how some of the complicating factors mentioned above (e.g., double flushing) influence water savings. This research is important in identifying weaknesses in field operation of ULFTs so that technology and installation practices can be improved.

It is possible to collect water end-use data using sophisticated and specialized metering devices. Although use of these devices is relatively expensive and generally not proven in the CII sector, we are optimistic that in the future useful end-use information will be forthcoming from other research investigations to help answer these types of detailed questions and serve to complement the results of this billing analysis study. In particular, we advocate using this type of approach with schools, where we found the billing analysis approach to be inherently limited with respect to the evaluation of water savings.

APPENDIX A
SIC CODE DEFINITIONS

D-046396

Table A-1
SIC Code Definitions

Code	Definition
Agricultural Services, Forestry, and Fishing	
07	Agricultural services
08	Forestry
09	Fishing, hunting, and trapping
Mining	
10	Metal mining
12	Coal mining
13	Oil and gas extraction
14	Nonmetallic minerals, except fuels
Construction	
15	General contractors and operative builders
16	Heavy construction, except building
17	Special trade contractors
Manufacturing	
20	Food and kindred
21	Tobacco products
22	Textile mill products
23	Apparel and other textile products
24	Lumber and wood products
25	Furniture and fixtures
26	Paper and allied products
27	Printing and publishing

Table A-1 (cont.)
SIC Code Definitions

Code	Definition
Manufacturing (cont.)	
28	Chemicals and allied products
29	Petroleum and coal products
30	Rubber and miscellaneous plastics products
33	Primary metal industries
34	Fabricated metal products
35	Industrial machinery and equipment
36	Electronic and other electronic equipment
37	Transportation equipment
38	Instruments and related products
39	Miscellaneous manufacturing industries
Transportation and Public Utilities	
41	Local and interurban passenger transit
42	Trucking and warehousing
44	Water transportation
45	Transportation by air
46	Pipelines, except natural gas
47	Transportation services
48	Communication
49	Electric, gas, and sanitary services

Table A-1 (cont.)
SIC Code Definitions

Code	Definition
Wholesale Trade	
50	Wholesale trade — durable goods
51	Wholesale trade — nondurable goods
Retail Trade	
52	Building materials and garden supplies
53	General merchandise stores
54	Food stores
55	Automotive dealers and service stations
56	Apparel and accessory stores
57	Furniture and homefurnishings stores
58	Eating and drinking places
59	Miscellaneous retail
Finance, Insurance, and Real Estate	
60	Depository
61	Nondepository institutions
62	Security and commodity brokers
63	Insurance carriers
64	Insurance agents, brokers, and service
65	Real estate
67	Holding and other investment

Table A-1 (cont.)
SIC Code Definitions

Code	Definition
Services	
70	Hotels and other lodging places
72	Personal services
73	Business services
75	Auto repair, services, and parking
76	Miscellaneous repair services
78	Motion pictures
79	Amusement and recreation services
80	Health services
81	Legal services
82	Educational services
83	Social services
84	Museums, botanical, zoological gardens
86	Membership organizations
87	Engineering and management services
89	Services, n.e.c.

Table A-1 (cont.)
SIC Code Definitions

Code	Definition
Public Administration	
91	Executive, legislative, and general government, except finance
92	Justice, public order, and safety
93	Public finance, taxation, and monetary policy
94	Administration of human resource programs
95	Administration of environmental quality and housing programs
96	Administration of economic programs
97	National security and international affairs
99	Nonclassifiable establishments

Source: Standard Industrial Classification Manual, 1987.

APPENDIX B
DEVELOPMENT OF NIR DATA

NIR equals reference evapotranspiration minus effective precipitation.

Reference evapotranspiration (ETo) is based on tall fescue grass that is actively growing, completely shading the soil, cut 4 to 6 inches high, and not limited by water. It is calculated from an empirical formula (modified Penman) using net radiation, air temperature, wind speed, and vapor pressure. We obtained daily values of ETo from CIMIS stations.

Effective precipitation (EP) is the amount of precipitation that effectively offsets ETo. It is precipitation minus water lost as runoff or lost to deep percolation. To calculate EP, we used a soil moisture balance equation. Based on a soil water holding capacity formula (Sprinkle and Trickle Irrigation, Chapter 3, by Jack Keller and Ron D. Bliesner, 1990), we calculated the soil water holding capacity assuming sandy loam soils, 0.5 management allowed deficit, and a 4 inch root zone depth (turfgrass).

> *Soil Water Holding Capacity = 125 mm/m for sandy loams × 0.012 to get inches/feet × 0.5 for management allowed deficit × 4/12 feet of effective root depth = 0.25 inches*

Hence, the resulting soil water holding capacity was set at 0.25 inches. This means that a large rainfall event is only capable of offsetting that day's ETo plus storing a maximum of 0.25 inches of water to the soil (depends on starting soil moisture conditions).

Using this approach 20 to 50 percent of precipitation is calculated to be effective at offsetting ETo on an annual basis. This large experienced variation is caused by large variations in the frequency and magnitude of rainfall events.

APPENDIX C
WATER AND SEWER PRICES

Table C-1
Water and Sewer Prices

Water Agency	Billing Cycle	Water Date	Water Block	Water $/Ccf	Sewer Date	Sewer Block	Sewer $/Ccf
Anaheim		7/1/96 to present		$0.43			
		9/1/95 to 7/1/96		$0.39			
		3/24/93 to 9/1/95		$0.32			
		1/1/92 to 3/24/93		$0.29			
San Diego	Monthly	7/1/95 to present		$1.44	10/1/96 to present		$1.71
		7/1/94 to 7/1/95		$1.35	7/1/94 to 10/1/96		$1.70
		7/1/93 to 7/1/94		$1.34	7/1/93 to 7/1/94		$1.60
		7/1/92 to 7/1/93		$1.23	7/1/92 to 7/1/93		$1.50
		11/8/91 to 7/1/92		$1.13	7/1/91 to 7/1/92		$1.43
		1/1/90 to 11/8/91		$0.99	7/1/90 to 7/1/91		$1.35
SDCWA-Helix	Bimonthly	1/1/96 to present		$1.66			
		1/1/95 to 1/1/96		$1.82			
		1/1/94 to 1/1/95		$1.77			
		1/1/93 to 1/1/94		$1.72			
		1/1/92 to 1/1/93		$1.59			
		1/1/91 to 1/1/92		$1.35			
SDCWA-Sweetwater	Bimonthly	1/1/96 to present		$1.93			
		1/1/95 to 1/1/96		$1.80			
		7/5/93 to 1/1/95		$1.68			
		5/11/92 to 7/5/93		$1.52			
		3/18/91 to 5/11/92		$1.36			
SDCWA-Vista	Bimonthly	1/1/96 to present		$1.47			
		1/1/94 to 1/1/96		$1.40			
		6/1/92 to 1/1/94		$1.35			
		7/1/91 to 6/1/92		$1.04			
		4/1/91 to 7/1/91		$0.90			
		9/1/90 to 4/1/91		$1.04			

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Table C-1 (cont.)
Water and Sewer Prices

		Water			Sewer		
Water Agency	**Billing Cycle**	**Date**	**Block**	**$/Ccf**	**Date**	**Block**	**$/Ccf**
Santa Monica[1]	Bimonthly	7/1/96 to present	1st	$0.97	7/1/96 to present		$1.12
			2nd	$2.25	4/1/92 to 7/1/96		$1.13
			3rd	$4.00			
		4/1/92 to 7/1/92	0 to 86 Ccf	$0.50			
			>86 Ccf	$0.97			
		1/1/91 to 4/1/92		$0.77			
SLO[2]	Monthly	7/1/96 to present	1 to 5 Ccf	$2.75	7/1/96 to present	1 to 5 Ccf	$0.00
			>5 Ccf	$3.45		>5 Ccf	$2.45
		7/1/95 to 7/1/96	1 to 5 Ccf	$2.65	7/1/95 to 7/1/96	1 to 5 Ccf	$0.00
			>5 Ccf	$3.35		>5 Ccf	$2.40
		7/1/94 to 7/1/95	1 to 5 Ccf	$2.60	7/1/94 to 7/1/95	1 to 5 Ccf	$0.00
			>5 Ccf	$3.25		>5 Ccf	$2.30
		10/1/93 to 7/1/94	1 to 5 Ccf	$2.45	7/1/93 to 7/1/94	1 to 5 Ccf	$0.00
			>5 Ccf	$3.05		>5 Ccf	$2.20
		3/93 to 10/1/93	1 to 5 Ccf	$2.25	7/1/92 to 7/1/93	1 to 5 Ccf	$0.00
			>5 Ccf	$2.80		>5 Ccf	$1.80
		8/90 to 3/93	1 to 5 Ccf	$1.20	7/1/91 to 7/1/92	1 to 5 Ccf	$0.00
			>5 Ccf	$2.40		>5 Ccf	$1.50
					7/1/90 to 7/1/91	1 to 5 Ccf	$0.00
						>5 Ccf	$1.30
Santa Barbara[3]		9/1/95 to present	0 to 100% Base	$3.50	June 1993 to present		$1.41
			>100% Base	$3.70			
		3/30/93 to 9/1/95	0 to 100% Base	$3.70			
			>100% Base	$5.10			

Table C-1 (cont.)
Water and Sewer Prices

Water Agency	Billing Cycle	Water Date	Water Block	Water $/Ccf	Sewer Date	Sewer Block	Sewer $/Ccf
Santa Barbara[3] (cont.)		9/24/91 to 3/30/93	0 to 50 Ccf	$3.70			
			>50 Ccf	$7.40			
		4/16/91 to 9/24/91	0 to 80% Base	$3.70			
			>80% Base	$12.00			
		10/9/90 to 4/16/91	0 to 70% Base	$3.70			
			>70% Base	$12.00			
Ventura[4]	Bimonthly	7/1/94 to present		$1.72	7/1/94 to present	1 to 8 Ccf	$0.00
						>8	$3.93
		7/1/93 to 7/1/94		$1.61	7/1/93 to 7/1/94	1 to 8 Ccf	$0.00
						>8	$3.82
		7/1/92 to 7/1/93		$1.56	7/1/92 to 7/1/93	1 to 8 Ccf	$0.00
						>8	$3.82
		7/1/90 to 7/1/92		$1.26	7/1/90 to 7/1/92	1 to 8 Ccf	$0.00
						>8	$3.65
EBMUD[5]		6/1/96 to present		$1.65	6/1/96 to present		$0.93
		6/1/95 to 6/1/96		$1.56	6/1/95 to 6/1/96		$0.90
		6/1/94 to 6/1/95		$1.34	6/1/94 to 6/1/95		$0.84
		6/1/93 to 6/1/94		$1.29	6/1/93 to 6/1/94		$0.90
		6/1/92 to 6/1/93		$1.30	6/1/92 to 6/1/93		$0.78
		6/1/91 to 6/1/92		$1.30	6/1/91 to 6/1/92		$0.72
		6/1/90 to 6/1/91		$0.91	6/1/90 to 6/1/91		$0.67
Marin[6]	Bimonthly	6/24/93 to present	0 to 85%	$2.13			
			86 to 150%	$3.94			
			>150%	$7.56			
		8/25/92 to 6/24/93	0 to 100%	$3.35			
			101 to 110%	$6.50			
			>110%	$8.75			

Table C-1 (cont.)
Water and Sewer Prices

Water Agency	Billing Cycle	Water			Sewer[4]		
		Date	Block	$/Ccf	Date	Block	$/Ccf
Marin[6] (cont.)	Bimonthly	1/1/92 to 8/25/92	0 to 75%	$4.25			
			76 to 80%	$6.50			
			81 to 90%	$8.75			
			91 to 95%	$11.00			
			>96%	$13.50			
		5/1/92 to 1/1/92	0 to 75%	$2.50			
			76 to 80%	$3.50			
			81 to 90%	$4.50			
			91 to 95%	$5.50			
			>96%	$6.50			
		9/1/90 to 5/1/91	0 to 80%	$2.20			
			80 to 100%	$3.08			
			>100%	$3.96			
San Francisco[7]		7/1/96 to present		$1.26	7/1/96 to present		$5.28
		7/1/95 to 7/1/96		$1.19	7/1/95 to 7/1/96		$5.09
		7/1/94 to 7/1/95		$1.17	7/1/94 to 7/1/95		$4.79
		7/1/93 to 7/1/95		$1.17	7/1/93 to 7/1/95		$4.48
		7/1/92 to 7/1/93		$1.02	7/1/92 to 7/1/93		$4.25
		7/1/91 to 7/1/92		$0.90	7/1/91 to 7/1/92		$3.84
		7/1/90 to 7/1/91		$0.94	7/1/90 to 7/1/91		$3.03

1. Santa Monica blocks based on meter size starting 7/1/96.
2. SLO had different rates for hotels/motels and Restaurants prior to 7/1/94.
3. Santa Barbara has its base equal to 1985-86 water use until 7/1/93 when it equals most recent January to June average.
4. Sewer rates shown are for restaurants.
5. EBMUD sewer rate does not include local collection charges.
6. MMWD base water use determined to be higher of 1981-1987 and 1986-87 average water use.
7. San Francisco rates based on averages.

D-046407

APPENDIX D
CUWCC ULFT FINAL TELEPHONE SURVEY

D-046408

Introduction

Hello, my name is [NAME] and I am calling on behalf of [WATER AGENCY]. May I please speak with [CONTACT NAME]?

1 Contact Person On Phone [CONTINUE]
2 Contact Person Not Available [RECORD TIME TO CALL BACK]
3 Contact Person No Longer There→I Am Conducting A Very Brief Survey On Behalf Of [WATER AGENCY] customers that participated in our Ultra-Low Flush Toilet retrofit program. Who At Your Facility Took Over Duties For [CONTACT NAME] Or Who Is The Building Site Manager?

  1 Contact Person Available [RECORD NEW CONTACT NAME]
  2 Contact Person Not Available [RECORD CALLBACK TIME]
  3 Refuses [THANK AND TERMINATE]

4 Refuses [THANK AND TERMINATE]

I am conducting a brief survey on behalf of [WATER AGENCY] customers who participated in our ultra-low flush toilet retrofit program. The information I have from agency records indicates that [CUSTOMER NAME] located at [STREET ADDRESS] participated in the retrofit program on [RETROFIT DATE]. Is this information correct?

1 Yes [CONTINUE]
2 No, Incorrect Customer Name [RECORD CORRECT CUSTOMER NAME; PROBE TO SEE IF ACTUALLY PARTICIPATED IN ULFT PROGRAM; IF NOT TERMINATE]
3 No, Incorrect Street Address [RECORD CORRECT STREET ADDRESS; PROBE TO ENSURE ULFTS ACTUALLY INSTALLED AT SITE AND THAT SITE IS CLOSE TO LISTED ADDRESS; IF NOT, TERMINATE]
4 I do not Know, Talking With Wrong Person [RECORD NEW CONTACT NAME AND START OVER]

[IF NECESSARY: REASSURE THAT THIS IS NOT A SALES CALL]
Before I begin, I would like to assure you that your responses will be kept strictly confidential and that your name will never be associated with your response. All responses will be combined to reflect the water use of businesses in California. This should take less than 5 minutes.

[IF NECESSARY: You may call [CONTACT NAME] OF [WATER AGENCY] at [PHONE NUMBER] to confirm that we are conducting a survey for them.]

[IF NECESSARY: This study will examine the efficiency and customer satisfaction with ultra-low flow toilets. It will assist [AGENCY] in designing better conservation programs for its customers.]

Survey Questions

[NOTE: For each question asked, the interviewer will have the option of recording a "d" for don't know and a "r" for refused. These options will NOT be offered to the respondent unless they are listed in the instrument as a valid response]

Q1 Before I start, I want to verify your business type. The information I have classifies your facility at [STREET ADDRESS] as [SUBCLASS]. Does that seem appropriate or is there a better general site description? [LOCATE DETAILED DESCRIPTION HERE]

1 Description is appropriate
2 Description is not appropriate [RECORD NEW SUBCLASS]

Q2 Our records indicate that [ULFT#] ultra-low flush toilet(s) was/were installed on [RETROFIT DATE]. Is that correct?

1 Correct
2 Incorrect number [RECORD CORRECT NUMBER]
3 Incorrect date [RECORD CORRECT DATE]
4 Know some were installed but unsure of the number/date
5 Has no idea if any were installed [ASK TO SPEAK WITH SOMEONE ELSE]

Q3 There are 2 general types of toilets installed in non-residential settings. The first is a tank type. The other does not have a tank but just a flush valve. How many of the [ULFT#] ultra-low flush toilets were tank type and how many were flush valve? [TANK TYPE TOILETS HAVE A WATER TANK ATTACHED TO EACH UNIT AND ARE SIMILAR TO THE TOILETS FOUND IN RESIDENTIAL SETTINGS. FLUSH VALVE TOILETS DO NOT HAVE TANKS AND ARE VERY COMMON IN COMMERCIAL SETTINGS]

____ Tank Type
____ Flush Valve

If [TOILET COUNT] is populated, ask Q4A else Q4B

Q4A Our records show that there are [TOILET COUNT] toilets at this site. Does that sound correct?

1 Yes [GOTO Q4C]
2 No [RECORD NEW TOILET COUNT]

Q4B How many <u>total</u> toilets are there at this location?

____	Toilets	[ANSWER HAS TO BE >= ULFT#]
D	Don't know	[GOTO Q5A]

If [ULFT#] is the same as [TOILET COUNT], skip to Q5A; else continue with Q4C

Q4C Based on what you have told me, [ULFT#] of the [TOILET COUNT] toilets at this site were changed as part of our program. Are any of these other toilets also of the ultra-low flush type?

1	Yes	
2	No	[GOTO Q5A]
D	Don't Know	[GOTO Q5A]

Q4D How many of these other [TOILET COUNT - ULFT#] toilets are ultra-low flush?

____ Ultra-Low Flush

Q4E When were these other toilets retrofitted to be ultra-low flush? [BE AS SPECIFIC AS POSSIBLE, ALLOW FOR MULTIPLE DATES]

____ Month/Year or Year or Pre/Post [RETROFIT DATE]
____ Month/Year or Year or Pre/Post [RETROFIT DATE]

Q5A In our study we need to account for outdoor water consumption. Does your facility have outside landscaping which is irrigated?

1	Yes	
2	No	[GOTO Q6A]

Q5B Does your facility have a separate irrigation meter that records water consumption for outside landscape watering?

1	Yes	[GOTO Q6A]
2	No	
D	Don't know	

Q5C In the past 5 years, have there been any significant changes in the size of your landscape or irrigation system, or other changes in your irrigated landscape practices or management?

1	Yes	[SPECIFY]
2	No	[GOTO Q6A]

Q5D When did this/these change(s) occur? [BE AS SPECIFIC AS POSSIBLE, ALLOW MULTIPLE RESPONSES]

____ Month/Year 1 or Year or Pre/Post [RETROFIT DATE]
____ Month/Year 2 or Year or Pre/Post [RETROFIT DATE]

Q5E Did this change/these changes tend to increase or decrease your overall water usage by more than 10 percent?

1	Yes, increased	[RECORD ESTIMATED % CHANGE IF OFFERED]
2	Yes, decreased	[RECORD ESTIMATED % CHANGE IF OFFERED]
3	No	

Q6A What is the approximate total enclosed square footage of floor space your business occupies and/or manages at this site?

____ Square Feet

(IF DON'T KNOW→Is it 1,000 square feet or less, 1,001 to 5,000 square feet, 5,001 to 10,000 square feet, 10,001 to 25,000 square feet, 25,001 to 50,000 square feet, 50,001 to 100,000 square feet, 100,001 to 200,000 square feet, 200,001 to 500,000 square feet, 500,001 to 1 million square feet, or over 1 million square feet?

1	1,000 square feet or less
2	1,001 to 5,000 square feet
3	5,001 to 10,000 square feet
4	10,001 to 25,000 square feet
5	25,001 to 50,000 square feet
6	50,001 to 100,000 square feet
7	100,001 to 200,000 square feet
8	200,001 to 500,000 square feet
9	500,001 to 1 million square feet
10	Over 1 million square feet

Q6B Over the last 5 years, has there been a significant increase or decrease in your square footage at this site?

1 Yes, increase
2 Yes, decrease
3 No [GOTO Q6D]

Q6BB By how many square feet did it [INCREASE/DECREASE]?

____ Square feet
D Don't know

Q6C When did this/these change(s) occur? [BE AS SPECIFIC AS POSSIBLE, ALLOW MULTIPLE RESPONSES]

____ Month/Year 1 or Year or Pre/Post [RETROFIT DATE]
____ Month/Year 2 or Year or Pre/Post [RETROFIT DATE]

Q6D Including yourself, approximately how many full-time and part-time persons are currently employed at this facility?

____ Total Employees

Q6E Of these [TOTAL EMPLOYEES], what percent are female?

____% Females

Q6E2 Over the last 5 years, has there been a significant increase or decrease in the percentage of females at this site?

1 Yes, increase
2 Yes, decrease
3 No [GOTO Q6F]

Q6E3 By what percent did it [INCREASE/DECREASE]?

____ Percent
D Don't know

Q6E4 When did this/these change(s) occur? [BE AS SPECIFIC AS POSSIBLE, ALLOW FOR MULTIPLE RESPONSES]

____ Month/Year 1 or Year or Pre/Post [RETROFIT DATE]
____ Month/Year 2 or Year or Pre/Post [RETROFIT DATE]

Q6F Over the last 5 years, has there been a significant increase or decrease in the TOTAL number of employees at this facility?

1 Yes, increase
2 Yes, decrease
3 No [GOTO Q6I]

Q6FF By how many employees did it [INCREASE/DECREASE]?

____ Employees
D Don't know

Q6G When did this/these change(s) occur? [BE AS SPECIFIC AS POSSIBLE, ALLOW FOR MULTIPLE RESPONSES]

____ Month/Year 1 or Year or Pre/Post [RETROFIT DATE]
____ Month/Year 2 or Year or Pre/Post [RETROFIT DATE]

[ASK ALL SUBCLASSES EXCEPT HOTELS [GOTO Q7A] AND SCHOOLS [GOTO Q8A]

Q6I Do non-employees use your bathroom facilities?

1 Yes
2 No [GOTO Q6J2]

Q6II In your opinion, approximately what percentage of all the bathroom use at this facility is by non-employees? (PROBE IF NECESSARY)

1 Less than 10%
2 At least 10% but less than 20%
3 At least 20% but less than 30%
4 At least 30% but less than 40%
5 At least 40% but less than 50%
6 At least 50% but less than 60%
7 At least 60% but less than 70%
8 At least 70% but less than 80%
9 At least 80% but less than 90%
10 At least 90%

[ASK Q6J2-Q6J ONLY OF RESTAURANTS]

Q6J2 How many meals do you serve in an average week?

____ meals [GOTO Q6JJ]
D don't know [GOTO Q6J]

Q6J Are you open for breakfast? Lunch? Dinner?

Breakfast	1 Yes	2 No
Lunch	1 Yes	2 No
Dinner	1 Yes	2 No

[ASK Q6JJ ONLY OF RETAIL]

Q6JJ Approximately how many total hours is this facility open to customers on a weekly basis?

____ Hours

Q6K Over the last 5 years, has there been a significant increase or decrease in the operating hours at this facility?

1 Yes, increase
2 Yes, decrease
3 No [GOTO Q7A]

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Q6KK By how many hours a week did it [INCREASE/DECREASE]?

____ Hours per week
D Don't know

Q6L When did this/these change(s) occur? [BE AS SPECIFIC AS POSSIBLE, ALLOW FOR MULTIPLE RESPONSES]

____ Month/Year 1 or Year or Pre/Post [RETROFIT DATE]
____ Month/Year 2 or Year or Pre/Post [RETROFIT DATE]

[ASK HOTELS Q7A-Q7C; SCHOOLS TO Q8A; ALL OTHERS TO Q9A]

Q7A How many guest rooms are there at this facility?

____ Rooms

Q7AA What is your average number of guests per room?

____ Guests per room

Q7B Over the last 5 years, has there been a significant increase or decrease in the number of guest rooms?

1 Yes, Increase
2 Yes, Decrease
3 No [GOTO Q9A]

Q7BB By how many guest rooms did it [INCREASE/DECREASE]?

____ Guest rooms
D Don't know

Q7C When did this/these change(s) occur? [BE AS SPECIFIC AS POSSIBLE, ALLOW MULTIPLE RESPONSES]

____ Month/Year 1 or Year or Pre/Post [RETROFIT DATE]
____ Month/Year 2 or Year or Pre/Post [RETROFIT DATE]

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[ASK SCHOOLS Q8A-Q8C; ALL OTHERS TO Q9A]

Q8A How many students attend this school?

____ Students

Q8B Over the last 5 years, has there been a significant increase or decrease in the number of students?

1 Yes, Increase
2 Yes, Decrease
3 No [GOTO Q9A]

Q8BB By how many students did it [INCREASE/DECREASE]?

____ Students
D Don't know

Q8C When did this/these change(s) occur? [BE AS SPECIFIC AS POSSIBLE, ALLOW MULTIPLE RESPONSES]

____ Month/Year 1 or Year or Pre/Post [RETROFIT DATE]
____ Month/Year 2 or Year or Pre/Post [RETROFIT DATE]

[ALL SUBCLASSES]

Q9A In order for us analyze water savings, we need to know if there have been any other changes at this site that may have impacted water consumption. Over the last 5 years, has there been a significant increase or decrease in any of the following?

A. (INDUSTRIAL ONLY) Changes in the production process	1 Yes	2 No
B. Change in efficiency level of urinals	1 Yes	2 No
C. Change in number of showers	1 Yes	2 No
D. Change in number of energy efficient faucet aerators or showerheads	1 Yes	2 No
E. Change in number of visitors	1 Yes	2 No
F. Extended interruptions in water service	1 Yes	2 No
G. Major water leaks	1 Yes	2 No
H. Other changes [SPECIFY]	1 Yes	2 No

[ASK Q9B and Q9C FOR EACH CHANGE INDICATED IN Q9A]

Q9B When did this change occur? [BE AS SPECIFIC AS POSSIBLE, ALLOW MULTIPLE RESPONSES]

____ Month/Year 1 or Year or Pre/Post [RETROFIT DATE]
____ Month/Year 2 or Year or Pre/Post [RETROFIT DATE]

Q9C Did this change tend to increase or decrease your overall water usage by more than 10 percent?

1 Yes, increased [RECORD ESTIMATED % CHANGE IF OFFERED]
2 Yes, decreased [RECORD ESTIMATED % CHANGE IF OFFERED]
3 No

Q10 Are there any factors at your site that would make your water consumption unusual relative to other [SUBCLASS] sites?

1 Yes [SPECIFY]
2 No

Q11 Was this facility built in the 1990s, 1980s, 1970s, 1960s or before?

1 1990s
2 1980s
3 1970s
4 1960s
5 Pre-1960

Q12A Finally, on a scale of 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied", how satisfied have you been with the performance of the ultra-low flush toilets?

1	2	3	4	5
Not At All Satisfied				Very Satisfied

Q12B Why do you say that? (PROBE: What have you or others been dissatisfied/satisfied with? ALLOW MULTIPLE RESPONSES)

1 Need To Double Flush
2 Toilets Clog
3 Need to be Cleaned More Often/Dirtier
4 They Save Water
5 Other [SPECIFY]

That's all the questions that I have. I'd like to thank you for your help with this study.

APPENDIX E
BILLING ANALYSIS MODEL OUTPUTS

Table E-1
Automotive Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-1.472	-4.32
NIR (net irrigation requirement)	0.716	5.59
Time trend	0.035	2.06
Central region interacted with 1st order sine harmonic	0.217	0.43
Central region interacted with 1st order cosine harmonic	1.691	2.91
Central region interacted with 2nd order sine harmonic	-0.019	-0.07
Central region interacted with 2nd order cosine harmonic	0.043	0.15
Southern region interacted with 1st order sine harmonic	-0.067	-0.31
Southern region interacted with 1st order cosine harmonic	0.781	2.61
Southern region interacted with 2nd order sine harmonic	-0.031	-0.28
Southern region interacted with 2nd order cosine harmonic	-0.067	-0.61
Northern region interacted with 1st order sine harmonic	-3.208	-2.78
Northern region interacted with 1st order cosine harmonic	-3.113	-2.66
Northern region interacted with 2nd order sine harmonic	-0.859	-1.37
Northern region interacted with 2nd order cosine harmonic	0.549	0.87
Indicator variable denoting a decrease in operating hours	-2.751	-1.36

Number of Observations: 1,421.
Partial R-Square: 0.06.
Dependent Variable: Monthly CCF water use.

Note to Regression Tables: two types of R-square values are associated with fixed-effects panel models, the partial R-square and the full R-square. The partial R-square represents the amount of variation in the deviation from mean water use that is explained by the model, whereas the full R-square is the amount of explained variation in the level of total water use. In the regression tables presented in this appendix we indicate the value of the partial R-square for each regression. Since there is a limited amount of information specific to each customer that varies over time, it is expected that the partial R-square values for this type of panel model will tend to be relatively low. (For most of the regression results shown in this appendix, however, the partial R-square values are higher than one might expect based on panel model results from similar evaluations.) Since the models include facility-specific intercept terms, the full R-square values (not reported) are expected to be on the order of 0.95 to 0.99. For panel models in general, neither R-square value provides conclusive information about the explanatory power of the model. To judge the explanatory power of the water savings models, the appropriate test statistic of interest is the t-statistic on the number of ULFTs installed.

Table E-2
Food Store Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-1.943	-7.09
NIR (net irrigation requirement)	0.584	4.31
Time trend	0.102	5.41
Central region interacted with 1st order sine harmonic	-0.696	-0.89
Central region interacted with 1st order cosine harmonic	-0.412	-0.50
Central region interacted with 2nd order sine harmonic	0.168	0.37
Central region interacted with 2nd order cosine harmonic	-0.347	-0.78
Southern region interacted with 1st order sine harmonic	-0.878	-1.49
Southern region interacted with 1st order cosine harmonic	-1.084	-1.72
Southern region interacted with 2nd order sine harmonic	0.461	1.36
Southern region interacted with 2nd order cosine harmonic	-0.693	-2.08
Northern region interacted with 1st order sine harmonic	-0.050	-0.18
Northern region interacted with 1st order cosine harmonic	0.979	2.26
Northern region interacted with 2nd order sine harmonic	0.032	0.23
Northern region interacted with 2nd order cosine harmonic	-0.264	-1.95
Indicator variable denoting a major water leak resulting in a increase in water use	11.193	1.60

Number of Observations: 919.
Partial R-Square: 0.12.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-3
Health Care Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-0.838	-4.74
NIR (net irrigation requirement)	0.725	4.59
Time trend	-0.008	-0.37
Central region interacted with 1st order sine harmonic	0.754	1.72
Central region interacted with 1st order cosine harmonic	1.356	2.39
Central region interacted with 2nd order sine harmonic	-0.116	-0.50
Central region interacted with 2nd order cosine harmonic	-0.191	-0.84
Southern region interacted with 1st order sine harmonic	-1.738	-4.56
Southern region interacted with 1st order cosine harmonic	-1.490	-3.29
Southern region interacted with 2nd order sine harmonic	0.054	0.26
Southern region interacted with 2nd order cosine harmonic	-0.086	-0.42
Northern region interacted with 1st order sine harmonic	0.316	0.55
Northern region interacted with 1st order cosine harmonic	0.115	0.17
Northern region interacted with 2nd order sine harmonic	-0.493	-1.62
Northern region interacted with 2nd order cosine harmonic	-1.009	-3.23
Indicator variable denoting an increase in operating hours	2.832	1.27
Indicator variable denoting an increase in the percentage of female employees	4.678	2.73

Number of Observations: 1,731.
Partial R-Square: 0.09.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-4
Hotel/Motel Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-0.643	-5.64
NIR (net irrigation requirement)	6.999	9.11
Time trend	-0.185	-2.19
Central region interacted with 1st order sine harmonic	-21.840	-8.94
Central region interacted with 1st order cosine harmonic	-13.382	-4.55
Central region interacted with 2nd order sine harmonic	5.026	3.60
Central region interacted with 2nd order cosine harmonic	-7.132	-5.09
Southern region interacted with 1st order sine harmonic	-2.183	-1.80
Southern region interacted with 1st order cosine harmonic	4.312	2.44
Southern region interacted with 2nd order sine harmonic	2.521	3.88
Southern region interacted with 2nd order cosine harmonic	-0.844	-1.31
Northern region interacted with 1st order sine harmonic	-68.133	-5.22
Northern region interacted with 1st order cosine harmonic	-79.077	-5.89
Northern region interacted with 2nd order sine harmonic	11.308	0.97
Northern region interacted with 2nd order cosine harmonic	-20.738	-1.86
Indicator variable denoting an increase in the number of visitors	11.157	2.48

Number of Observations: 1,748.
Partial R-Square: 0.29.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-5
Manufacturing Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-0.948	-4.70
NIR (net irrigation requirement)	0.629	3.31
Time trend	-0.023	-1.09
Southern region interacted with 1st order sine harmonic	-0.365	-1.30
Southern region interacted with 1st order cosine harmonic	0.473	1.15
Southern region interacted with 2nd order sine harmonic	-0.113	-0.80
Southern region interacted with 2nd order cosine harmonic	-0.094	-0.67
Northern region interacted with 1st order sine harmonic	0.502	0.74
Northern region interacted with 1st order cosine harmonic	0.599	0.75
Northern region interacted with 2nd order sine harmonic	-0.358	-1.05
Northern region interacted with 2nd order cosine harmonic	-0.128	-0.36
Indicator variable denoting an increase in the percentage of female employees	2.244	1.47
Indicator variable denoting a decrease in the number of employees	-4.191	-1.74
Indicator variable denoting a decrease in production at the facility	-8.903	-1.42

Number of Observations: 1,168.
Partial R-Square: 0.05.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-6
Miscellaneous Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-0.690	-4.56
NIR (net irrigation requirement)	0.868	5.25
Time trend	0.038	2.15
Central region interacted with 1st order sine harmonic	0.106	0.20
Central region interacted with 1st order cosine harmonic	1.629	2.45
Central region interacted with 2nd order sine harmonic	0.214	0.75
Central region interacted with 2nd order cosine harmonic	-0.257	-0.92
Southern region interacted with 1st order sine harmonic	-0.812	-2.27
Southern region interacted with 1st order cosine harmonic	0.267	0.60
Southern region interacted with 2nd order sine harmonic	0.167	0.83
Southern region interacted with 2nd order cosine harmonic	-0.430	-2.15
Northern region interacted with 1st order sine harmonic	-0.348	-0.66
Northern region interacted with 1st order cosine harmonic	2.009	3.06
Northern region interacted with 2nd order sine harmonic	-0.766	-2.56
Northern region interacted with 2nd order cosine harmonic	-0.222	-0.74
Indicator variable denoting a decrease in operating hours	-22.712	-4.22

Number of Observations: 1,644.
Partial R-Square: 0.06.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-7
Multiple Use Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-1.199	-3.17
NIR (net irrigation requirement)	2.011	3.17
Time trend	0.369	3.29
Central region interacted with 1st order sine harmonic	0.488	0.16
Central region interacted with 1st order cosine harmonic	7.893	2.52
Central region interacted with 2nd order sine harmonic	1.080	0.71
Central region interacted with 2nd order cosine harmonic	2.102	1.35
Southern region interacted with 1st order sine harmonic	-1.427	-0.37
Southern region interacted with 1st order cosine harmonic	0.903	0.23
Southern region interacted with 2nd order sine harmonic	1.309	0.67
Southern region interacted with 2nd order cosine harmonic	0.328	0.16
Northern region interacted with 1st order sine harmonic	-0.248	-0.20
Northern region interacted with 1st order cosine harmonic	2.617	1.33
Northern region interacted with 2nd order sine harmonic	-1.940	-3.54
Northern region interacted with 2nd order cosine harmonic	0.585	1.07
Indicator variable denoting a "other" change resulting in a decrease in water use	-3.876	-1.91
Indicator variable denoting a major water leak resulting in an increase in water use	21.532	3.00

Number of Observations: 538.
Partial R-Square: 0.09.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

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Table E-8
Office Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-0.821	-12.29
NIR (net irrigation requirement)	0.475	10.77
Time trend	0.008	1.31
Central region interacted with 1st order sine harmonic	-0.494	-2.94
Central region interacted with 1st order cosine harmonic	0.013	0.07
Central region interacted with 2nd order sine harmonic	-0.229	-2.48
Central region interacted with 2nd order cosine harmonic	-0.064	-0.70
Southern region interacted with 1st order sine harmonic	-0.561	-5.28
Southern region interacted with 1st order cosine harmonic	-0.059	-0.47
Southern region interacted with 2nd order sine harmonic	0.017	0.30
Southern region interacted with 2nd order cosine harmonic	-0.146	-2.62
Northern region interacted with 1st order sine harmonic	0.168	1.21
Northern region interacted with 1st order cosine harmonic	0.939	5.41
Northern region interacted with 2nd order sine harmonic	-0.096	-1.30
Northern region interacted with 2nd order cosine harmonic	-0.133	-1.80
Indicator variable denoting an increase in irrigation use	3.797	3.04
Indicator variable denoting a change in efficiency level of urinals resulting in a decrease in water use	-5.479	-1.72
Indicator variable denoting extended interruptions in water service resulting in an increase in water use	2.346	0.99
Indicator variable denoting major water leaks resulting in an increase in water use	1.744	1.71

Number of Observations: 9,072.
Partial R-Square: 0.06.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-9
Religious Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-1.148	-5.62
NIR (net irrigation requirement)	2.078	10.84
Time trend	0.106	4.28
Central region interacted with 1st order sine harmonic	1.251	1.73
Central region interacted with 1st order cosine harmonic	5.900	6.87
Central region interacted with 2nd order sine harmonic	-0.995	-2.44
Central region interacted with 2nd order cosine harmonic	0.838	2.10
Southern region interacted with 1st order sine harmonic	-3.928	-8.72
Southern region interacted with 1st order cosine harmonic	-1.334	-2.47
Southern region interacted with 2nd order sine harmonic	-0.225	-0.91
Southern region interacted with 2nd order cosine harmonic	0.707	2.91
Northern region interacted with 1st order sine harmonic	-1.560	-2.84
Northern region interacted with 1st order cosine harmonic	2.253	3.14
Northern region interacted with 2nd order sine harmonic	0.134	0.47
Northern region interacted with 2nd order cosine harmonic	0.042	0.15
Indicator variable denoting an increase in the number of employees	3.696	1.81

Number of Observations: 2,668.
Partial R-Square: 0.17.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-10
Restaurant Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-1.914	-7.16
NIR (net irrigation requirement)	1.520	9.66
Time trend	0.037	2.32
Central region interacted with 1st order sine harmonic	0.566	1.55
Central region interacted with 1st order cosine harmonic	3.009	5.68
Central region interacted with 2nd order sine harmonic	-0.088	-0.45
Central region interacted with 2nd order cosine harmonic	0.319	1.61
Southern region interacted with 1st order sine harmonic	0.026	0.07
Southern region interacted with 1st order cosine harmonic	1.071	2.50
Southern region interacted with 2nd order sine harmonic	0.319	1.63
Southern region interacted with 2nd order cosine harmonic	-0.463	-2.36
Northern region interacted with 1st order sine harmonic	-0.428	-0.73
Northern region interacted with 1st order cosine harmonic	1.465	2.09
Northern region interacted with 2nd order sine harmonic	-0.085	-0.27
Northern region interacted with 2nd order cosine harmonic	-0.126	-0.40
Indicator variable denoting a decrease in operating hours	-8.952	-1.70
Indicator variable denoting a "other" change resulting in an increase in water use	15.397	5.01
Indicator variable denoting a major water leak resulting in a decrease in water use	-7.204	-1.80

Number of Observations: 3,134.
Partial R-Square: 0.09.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-11
Retail Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-1.519	-12.98
NIR (net irrigation requirement)	0.178	3.52
Time trend	0.020	3.15
Central region interacted with 1st order sine harmonic	-0.068	-0.57
Central region interacted with 1st order cosine harmonic	0.059	0.36
Central region interacted with 2nd order sine harmonic	-0.144	-2.25
Central region interacted with 2nd order cosine harmonic	-0.008	-0.13
Southern region interacted with 1st order sine harmonic	-0.301	-2.90
Southern region interacted with 1st order cosine harmonic	0.041	0.31
Southern region interacted with 2nd order sine harmonic	0.017	0.30
Southern region interacted with 2nd order cosine harmonic	-0.142	-2.61
Northern region interacted with 1st order sine harmonic	-0.586	-1.35
Northern region interacted with 1st order cosine harmonic	0.291	0.66
Northern region interacted with 2nd order sine harmonic	-0.254	-1.05
Northern region interacted with 2nd order cosine harmonic	-0.002	-0.01
Indicator variable denoting an increase in operating hours	10.179	2.49
Indicator variable denoting a "other" change resulting in an increase in water use	2.674	1.71
Indicator variable denoting extended interruptions in water service resulting in a decrease in water use	-12.304	-3.98

Number of Observations: 4,289.
Partial R-Square: 0.06.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

Table E-12
Wholesale Market Segment

Independent Variable	Parameter Estimate	t-statistic
Number of ULFTs installed through the program	-2.309	-2.51
NIR (net irrigation requirement)	1.223	3.16
Time trend	0.057	1.09
Central region interacted with 1st order sine harmonic	0.116	0.07
Central region interacted with 1st order cosine harmonic	2.572	1.38
Central region interacted with 2nd order sine harmonic	0.238	0.28
Central region interacted with 2nd order cosine harmonic	-0.032	-0.04
Southern region interacted with 1st order sine harmonic	-2.319	-3.39
Southern region interacted with 1st order cosine harmonic	-0.993	-1.08
Southern region interacted with 2nd order sine harmonic	0.236	0.59
Southern region interacted with 2nd order cosine harmonic	-0.673	-1.68

Number of Observations: 288.
Partial R-Square: 0.18.
Dependent Variable: Monthly CCF water use.
Note: Please refer to Table E-1.

APPENDIX F
BACKGROUND ON PLUMBING CODES

Title 24 of the California Code of Regulations entitled "The California Building Standards Code" (CBSC) sets forth the minimum standards for the number of sanitation fixtures to be included in structures of all types that are governed by the code. The code contains 12 parts and incorporates by reference many model codes developed by a number of nonprofit associations in the United States. Two of these germane to plumbing standards are the Uniform Building Code (UBC) published by the International Conference of Building Officials and the Uniform Plumbing Code (UPC) published by the International Association of Plumbing and Mechanical Officials. California has currently adopted the 1994 editions of each of these two model codes. The CBSC also contains amendments to each of the model codes. The amendments to the UBC are found in Part 2 of the CBSC and, together with the UBC, constitute the California Building Code (CBC). The amendments to the UPC are found in Part 5 of the CBSC and, together with the UPC, constitute the California Plumbing Code (CPC). The state authority responsible for promulgating and updating the CBSC is the California Building Standards Commission. In 1989, Section 18938 (b) of the state's Health and Safety Code became effective. It made the standards contained in the various model codes adopted by reference in the CBSC applicable to all occupancies throughout the state.[1]

Government Code Section 50022 and Health and Safety Code Section 17922 provide cities and counties with the authority and mandate to adopt the CBSC referenced model codes. Furthermore, these local entities have authority to make reasonable and justifiable amendments to the codes.

Two important sets of tables exist in the codes. The first set, entitled "Minimum Plumbing Facilities," is contained in Appendix C of the UPC. The CBSC further amends Appendix C by adding Tables C-1, C-2, C-3, and C-4. Together, these tables establish the minimum number of plumbing facilities (toilets, urinals, lavatories, bathtubs, showers, and drinking fountains) for the various types of occupancies. The second set, entitled "Minimum Plumbing Fixtures," appears in the 1994 UBC as Table A-29-A. The two tables are not in exact agreement. Both are, for the most part, based on total occupant loads expressed in terms of "fixtures per number of occupants" (i.e., toilets per number of employees, patrons, students, patients, or prisoners). The California amendments state that occupant load is to be determined by minimum exiting requirements. Table A-29-A goes one step further and ties occupant load to structure area, which is useful for

1. Telephone/fax communications with Stan Nishimura, Codes Manager, California Building Standards Commission.

the purposes of this study. While very similar, where there are differences between the two sets of tables, Table A-29-A generally requires slightly more fixtures. Table A-29-A, currently, has not been adopted by the California Building Standards Commission as part of CPC.

Requirements for access compliance for disabled persons are also contained in Title 24 of the California Code of Regulations. These provisions are reported to be substantially the same as provisions of the federal Americans with Disabilities Act of 1992 (ADA). In late 1996, the state submitted these provisions to the U.S. Department of Justice to determine if California is in compliance with the ADA. The Attorney General of California has issued an opinion that local city, county, and state agencies must retrofit their own restrooms to comply with the ADA but are not compelled to enforce the provisions of the ADA on others. When an application for a building permit (including permits for building modifications) is received, however, the applicant is required to meet the access compliance requirements for disabled persons contained in Title 24. Complaints by citizens lodged against owners of places of public accommodation who have not complied with the ADA are referred to a federal marshal.

Table F-1 contains building and plumbing code details used to derive the driver coefficients in Table 3-1.

Table F-1
Building and Plumbing Code Details

CII Market Segment	SIC Code	Data Driver	Employees: Toilets		Visitors: Toilets		Visitors:Employee
			Male	Female	Male	Female	
Commercial							
1. Assembly Places - Theatres, Auditoriums	 783	Employees	1-15:1 16-35:2 36-55:3 >55, 40:1	1-15:1 16-35:3 36-55:4 >55, 40:1	1-100:1 101-200:2 201-400:3 >400, 500:1	1-50:3 51-100:4 101-200:8 201-400:11 >400, 125:1	13.3:1
2. Eating and Drinking Places	58	Employees			1-50:1 51-150:2 151-300:3 >300, 200:1	1-50:1 51-150:2 151-300:4 >300, 200:1	6.7:1
3. Hotels/Motels	70 (not 703)	Guest rooms			1 toilet per rental unit		
4. Offices - Finance, Insurance, Real Estate - Business Services - Legal Services - Membership Organ. - Engineering and Management	 60-67 73 81 86 (not 866) 87-89	Employees	1-15:1 16-35:2 36-55:3 >55, 40:1	1-15:1 16-35:3 36-55:4 >55, 40:1	1-100:1 101-200:2 201-400:3 >400, 500:1	1-50:3 51-100:4 101-200:8 201-400:11 >400, 150:1	1:1
5. Retail/Wholesale - Wholesale - Retail - Personal Services - Auto &Misc. Repair	 50-51 52-57, 59 72 75, 76	Employees	1-15:1 16-35:2 36-55:3 >55, 40:1	1-15:1 16-35:3 36-55:4 >55, 40:1	1-50:1 51-100:2 101-400:3 >400, 500:1	1-50:1 51-100:2 101-200:3 201-300:4 301-400:5 >400, 150:1	1:1
Industrial							
6. Industrial	20-39	Employees	1-10:1 11-25:2 26-50:3 51-75:4 76-100:5 >100, 30:1	1-10:1 11-25:2 26-50:3 51-75:4 76-100:5 >100, 30:1			
Institutional							
7. Churches	866	Employees			150:1	75:1	45.7:1
8. Education - Primary School - Other	82	Students			 30 per 1 40 per 1	 25 per 1 30 per 1	
9. Government	90-98	Employees	1-15:1 16-35:2 36-55:3 >55, 40:1	1-15:1 16-35:3 36-55:4 >55, 40:1	25:1	20:1	1:1
10. Health Services - Hospitals - Clinics	80	Employees	1-15:1 16-35:2 36-55:3 >55, 40:1	1-15:1 16-35:3 36-55:4 >55, 40:1	1 toilet per room		
11. Other	All codes not listed elsewhere	Employees	1-15:1 16-35:2 36-55:3 56-80:4 81-110:5 111-150:6 >150, 40:1	1-15:1 16-35:2 36-55:3 56-80:4 81-110:5 111-150:6 >150, 40:1			

In addition to the codes, we assume 200 ft2 per employee for restaurants and retail.
Also assume 1,372 ft2 per employee for churches based on MWD and CUWCC databases.